Progress thru Research

ANNUAL REPORT - 1957

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FORT COLLINS, COLORADO
Raymond Price, Director

U. S. DEPARTMENT OF AGRICULTURE
Forest Service

LOCATION OF FIELD UNITS

RESEARCH CENTERS

Albuquerque, New Mexico
Marron Hall
University of New Mexico

Flagstaff, Arizona
Arizona State College

Fort Collins, Colorado
Forestry Building
Colorado State University

Grand Junction, Colorado
Post Office Building

Laramie, Wyoming
Agriculture Building
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
South Dakota School of Mines and Technology

Tempe, Arizona
Agriculture Building
Arizona State College

Tucson, Arizona
Tumamoc Hill

FOREST INSECT AND DISEASE LABORATORIES

Albuquerque, New Mexico
Post Office Building

Fort Collins, Colorado
South Hall
Colorado State University

ANNUAL REPORT

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

CALENDAR YEAR 1957

The Station maintains central headquarters at Fort Collins, Colorado, in cooperation with Colorado State University

(Not for publication)

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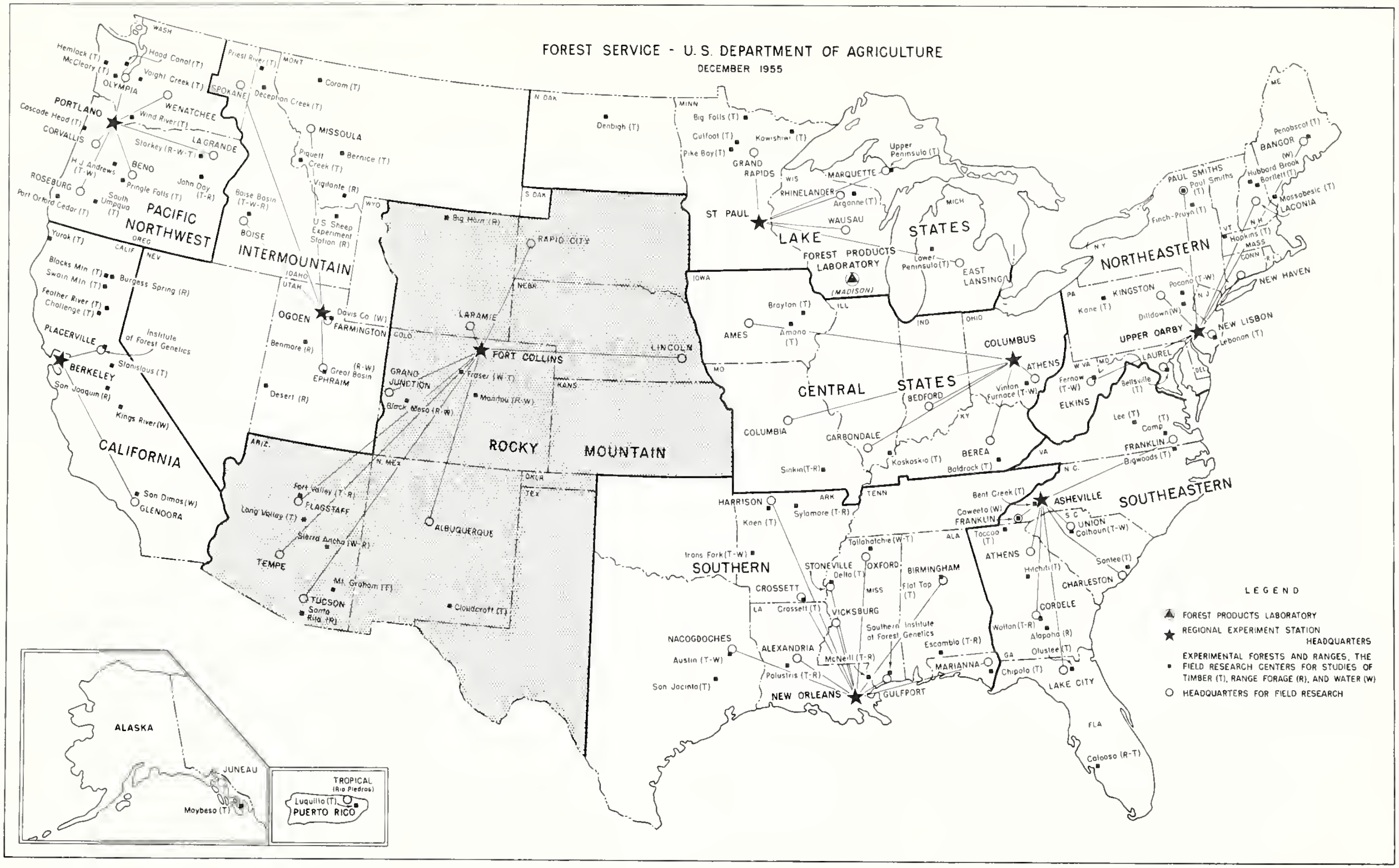

Figure 1. --Location of the forest and range experiment stations and the Forest Products Laboratory.

INTRODUCTION

The Rocky Mountain Forest and Range Experiment Station is one of nine regional forest and range experiment stations of the Forest Service, U. S. Department of Agriculture, in the continental United States. In addition, the Forest Service maintains the Forest Products Laboratory at Madison, Wisconsin, and research centers in Alaska and Puerto Rico (fig. 1).

Forest Service research pertains to all forest lands and the management of related nonforest rangelands, including State and private holdings as well as national forests and other Federal lands. The research covers a wide field of endeavor concerning protection and management of forests, related rangelands, wildlife habitat, and watersheds; utilization and marketing of forest products; and forest economics. Much of the research is carried out in cooperation with other Federal agencies, and with State and private agencies, organizations, institutions, and individuals.

As shown in figure 1, the territory served by the Rocky Mountain Forest and Range Experiment Station includes the States of Arizona, New Mexico, Colorado, Kansas, Nebraska, South Dakota, Wyoming, and the western part of Texas and Oklahoma. A multitude of forest and range types and problems, and watershed conditions are represented, ranging from deserts, through plains, foothills, mountains, and alpine areas. Also, distinct and varied cultural developments and practices are encountered.

The research of the station is organized under several divisions as follows: Forest Diseases, Forest Insects, Forest Management and Forest Fire, Forest Utilization and Economics, Watershed Management, and Wildlife Habitat and Range Management. Cooperation is also maintained with the Fish and Wildlife Service, U. S. Department of the Interior, for research in forest biology. Much of the research is concentrated at field research centers (see inside front cover for locations), including experimental forests and ranges and special laboratories where major problems may be studied advantageously. Advice and guidance regarding priorities of problems needing research are sought through organized research advisory committees made up of local citizens interested or engaged in forestry.

The need for research in the broad field of forestry or wildland husbandry in the Rocky Mountain area is great. It is a growing area with a big future ahead of it. Research has the opportunity and the challenge to lead, to make sure that development is along the right lines, to build rather than to remodel, to make positive advances. Progress in forestry is closely linked with research. As information is obtained to solve a particular problem another step forward is possible in better use and management of the resource.

Highlights of research findings by the station during the past year are presented in the following pages. A more detailed account of research results is released through various publications. An annotated list of publications issued in 1957 is included in the bibliography at the end of this report.

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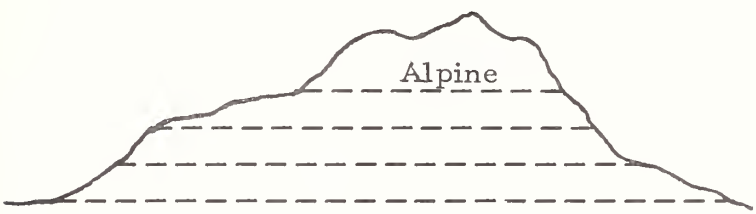
WATERSHED MANAGEMENT RESEARCH

From the high alpine areas of the Colorado Rockies to the dry deserts of the Southwest the question is being asked more and more frequently: How can we get more water? People are beginning to realize that without more water industry and agriculture cannot expand. This is a fact we must learn to live with.

Can our water supply be increased through manipulation and intensive management of forest and range lands on the watersheds and the snow that falls on them? Research has been intensified on this question during the past year. Some findings indicate ways that water yield can be increased, while others give a better understanding of how watersheds operate -- information that is needed in management.

Let's look at what we've found out. Starting up in the alpine, we'll work down through the spruce and lodgepole, the ponderosa pine, the woodland, and finish on the streambanks and flood plains.



The snowfields that dot the alpine landscape are important sources of late-season streamflow. We are studying these fields to learn how they can be increased in depth and extent and whether melting rates can be controlled. The heavy snows of 1957 doubled the areas of the fields under observation, and many snowfields that completely disappeared in 1955 and 1956 failed to melt out in 1957.

Alpine snowfields gain moisture from the air

Some men have contended that the alpine snow reservoirs have high rates of evaporation loss during summer months. Meteorological observations in 1955 and 1956 indicated that this loss should be slight because the snow surface temperatures were frequently lower than the dewpoint temperature. To check these calculations, direct measurements were made with plastic tanks loaded with weighed amounts of snow. These containers were placed level with the snowfield surface and provided with drains for melt water. After a period, remaining snow and the melt water were weighed. The difference between this weight and original weight was the quantity of evaporation or condensation. The results showed that in August 1957 condensation exceeded evaporation, and each acre of snow surface gained about 1,300 gallons of water a day (figs. W-1, W-2, and W-3).

Figure W-1.--Tanks made of plastic sheeting were used to measure the net moisture exchange between the air and an alpine snowfield. They were filled with 4,860 pounds of snow. A plastic tube carried melt water to a container from which it could be poured for frequent weighing. At the end of the period the combined weight of the melt water and the remaining snow exceeded the original snow weight, indicating that more moisture was gained by condensation than was lost by evaporation. The net gain was 0.37 inch of water per week for one lysimeter and 0.29 inch per week for the other. Hence under the conditions that prevailed during this period, each acre of snow milked about 1,300 gallons of water a day from the air.

Figure W-2.--Plexiglass containers were used to measure evaporation and condensation during short periods to detect extremes as well as diurnal trends. These units were 16 inches in diameter and about 16 inches tall, and were divided into two sections by a perforated hemispherical partition. The upper part of each unit was loaded with snow, then the entire unit weighed and buried to its rim in the snowfield. The maximum condensation rate was 0.0034 inch per hour, or 92 gallons per hour for each acre. Maximum evaporation was 0.0061 inch per hour, or 166 gallons per hour per acre. Moisture usually evaporated from the snow during the mornings and early afternoons and condensed during the nights. The condensation period was longer than that of evaporation, causing a net gain in weight by the snow.

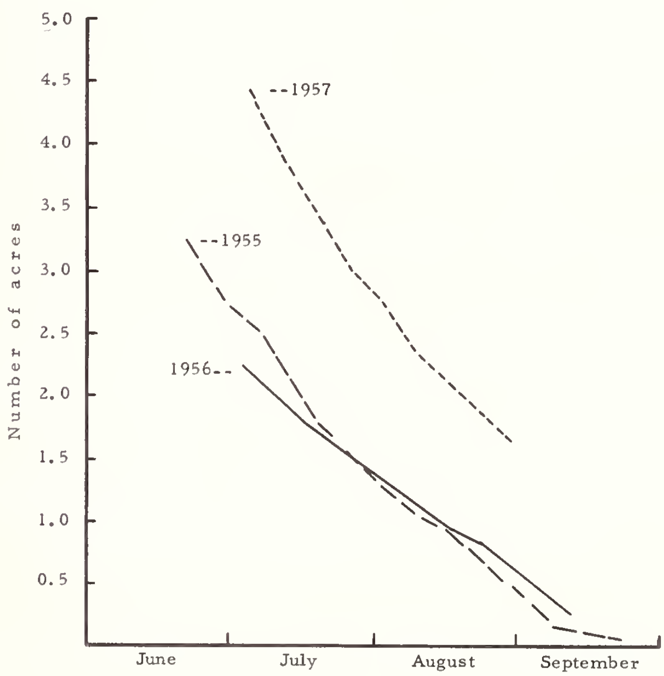
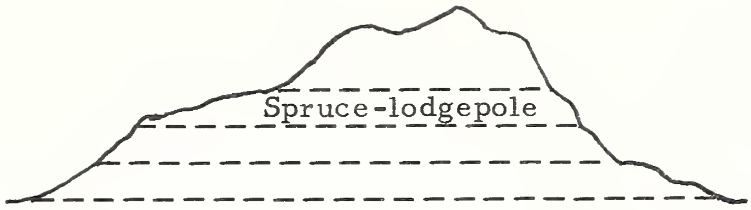


Figure W-3.--This graph shows the change in area of a snowfield on Mount Evans, Colorado, during each of the past 3 summer seasons. While the total area was much larger in 1957, it is significant that the slopes of the curves are similar, indicating similar rates of melting each summer. The rate of vertical shrinkage is also remarkably constant from year to year, averaging 1.5 feet per week.



Below timberline in the spruce-lodgepole type, two kinds of studies are being directed toward getting more water from the forests. The first of these is the well-known strip-cutting experiment on Fool Creek watershed of the Fraser Experimental Forest in central Colorado, which has resulted in increased water yield. The second study is of a more fundamental nature and involves direct measurements of snow interception by trees and the resulting evaporation loss.

Initial timber harvest causes increased streamflow

Logging of the Fool Creek watershed was completed in the fall of 1956. Trees were cut on 278 acres of the 714-acre watershed. A strip pattern of cutting was used as shown by figure W-4. For the period from the beginning of the spring freshet to September 30, streamflow was 200 acre-feet above the level estimated for the watershed from which no timber had been cut. Most of this increase was in the flow before July 1. In both 1956 and 1957 the rise began earlier than it did in previous years. The rate of flow at the peak of the spring flood was 50 percent higher than predicted in 1956, but in 1957 it was 23 percent lower. The early rapid melt associated with timber harvest spread the high runoff of 1957 over a longer time interval, reducing the height of the main flood peak (fig. W-5).

Snow interception and evaporation measured directly

Interception of falling snow by the trees and consequent evaporation have been the accepted explanations for the lesser snowpacks measured under forest canopies--also for the lower water yield from heavily forested watersheds. However, few if any direct measurements have been made to support this conclusion. A beginning was made on such observations in the studies illustrated in figures W-6 and W-7.

Figure W-4.--This is the way the Fool Creek watershed looks to those flying into Denver from the west. This kind of cutting pattern may be seen on an ever-increasing area because it benefits both water and timber production. Streamflow was increased 250 acre-feet in 1956 and 200 acre-feet in 1957 as a result of this treatment.

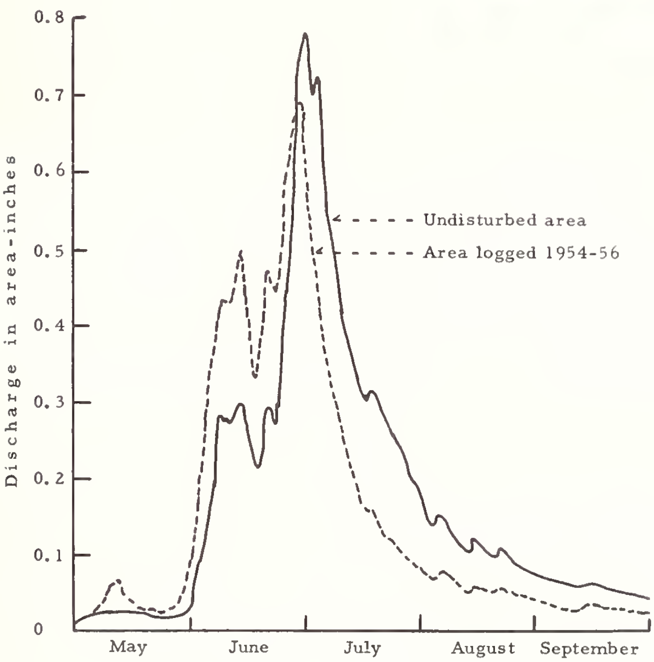


Figure W-5.--Comparison of streamflow from Fool Creek and the adjacent check watershed of 1,984 acres. Note the early rise in the hydrograph for the treated area caused by more rapid snowmelt on the cleared acreage. On both watersheds 1957 was an unusual year with abundant late spring snow. Total streamflow for the check area was 50 percent above the 14-year average and 20 percent greater than the previous high of 1952.

Figure W-6. --Mounted on scales, this 15-foot Engelmann spruce intercepted 36 pounds of snow during one snowstorm--7-1/2 inches of snow, with a water equivalent of 0.41 inch, fell in the storm.

Figure W-7. --The snow on this lodgepole pine branch was reduced by evaporation from 8 ounces to 3.5 ounces in 2 hours and 40 minutes. None of the snow was lost by falling off or by melting and drip.

Below the spruce and lodgepole the cover consists largely of aspen, ponderosa pine, and Douglas-fir. In our efforts to learn whether more water can be obtained from these forests, we have undertaken three types of studies. In the first we are interested in rooting characteristics, for the depth and density of its roots may have a lot to do with the amount of water the tree draws from the ground. The second type of study involves direct measurement of soil moisture during the growing season to learn how much water is actually removed by the plants. The third study measures the runoff that leaves a watershed. Treatments are varied to find out how streamflow is influenced by changes in plant cover.

Rooting characteristics

In the studies of rooting characteristics the following plants have been observed: Lodgepole pine, aspen, ponderosa pine, Douglas-fir, chaparral, mountain-mahogany, kinnikinnik, Arizona fescue, and mountain muhly. Results are summarized in the tabulation below. Two interesting findings are (1) roots of ponderosa pine in central Arizona are deeper than in the Colorado Front Range, and (2) many chaparral roots were found at 12 feet, the maximum depth that could be sampled.

Depth of sample in inches	Weight of roots in grams per cubic foot		
	Ponderosa pine	Pine-fir	Chaparral
0 - 2	160	233	74
2 - 4	54	65	57
4 - 6	11	20	21
6 - 8	5	15	24
8 - 10	1/ 5	7	8
10 - 12	1/ 1	1/ 3	1/ 13
12 - 14		1/ 1	
14 - 16		1/ 1	
16 - 18		1/ 0.2	

1/ Indicates auger sampling.

Trees and brush root deeply in Arizona diabase soil

Small roots were found to penetrate as deep as it was possible to take samples (12 feet) in three trenches dug on the Sierra Ancha Experimental Forest. One trench was under ponderosa pine and another under a mixed stand of ponderosa pine, white fir, Douglas-fir, and Gambel oak. At these sites the surface soil was medium textured with a granular structure. The subsoil was heavy textured with a massive structure when wet. Another trench was dug under a chaparral stand composed of shrub live oak, Wright silktassel, hollyleaf buckthorn, pinyon, skunkbush sumac, and desert ceanothus. The soil here was mainly coarse sand, and unweathered diabase was 10 to 12 feet below the surface. Soil samples were taken from the trench wall or, for the deeper layers, from auger borings in the bottom of the trench.

Aspen roots reach out

A different type of root study was made in Colorado at the Manitou Experimental Forest. Entire root systems of single trees were excavated. Depth of rooting was less than measured in Arizona, perhaps because at Manitou storms are smaller and there is less opportunity for deep penetration of moisture. Ponderosa pine, Douglas-fir, lodgepole pine, and aspen roots were studied for trees 20 to 30 feet in height, 70 to 90 years old, and 4 to 6 inches diameter breast height. Aspen roots had greatest lateral spread, with a maximum reach of 48 feet. All tree species penetrated to a depth of 5 feet, with no marked differences between them (figs. W-8 and W-9).

Soil moisture under ponderosa pine

In the Black Hills of South Dakota, as in Arizona, ponderosa pine roots penetrated more deeply than at Manitou in Colorado. Soil moisture sampling in June showed that in a 2-week period the trees pulled 2 inches of water from the layer of soil between 3 and 6 feet from the soil surface. The indicated use of water by a 65 to 70 year stand, which had 2,885 trees per acre, was about 0.3 inch of water per day during a period when there was abundant soil moisture in June. The use of 0.3 inch of water per day is based on the change in soil moisture and the measured

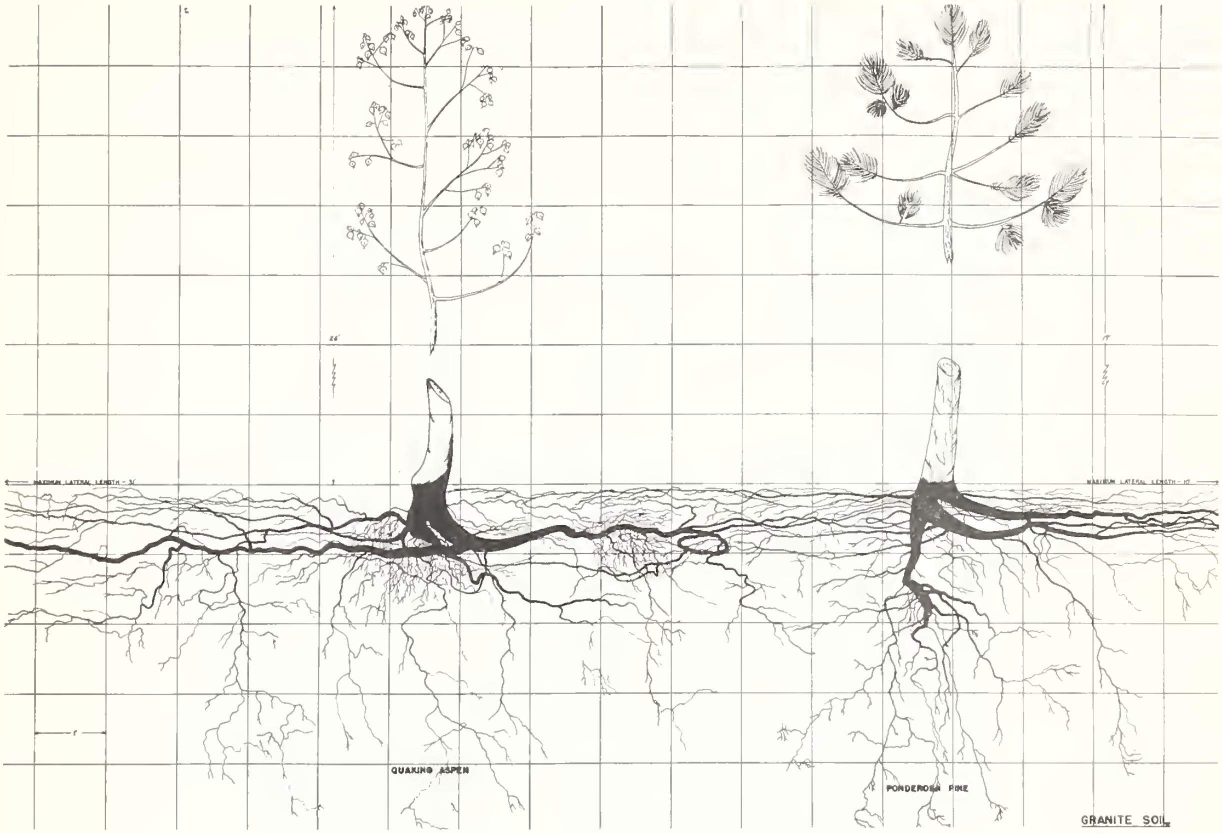


Figure W-8.--Root systems of aspen and ponderosa pine on soils derived from granite at Manitou Experimental Forest. Both trees rooted to the same 5-foot depth, but the aspen roots had reached a maximum length of 31 feet from the stump. The pine reached out only 10 feet. The aspen was 70 years old, 26 feet high, with a d.b.h. of 4.5 inches. The pine was 85 years old, 19 feet high, with 4.5 inches d.b.h. Lack of deep soil moisture rather than any other soil characteristic is believed to limit root penetration.

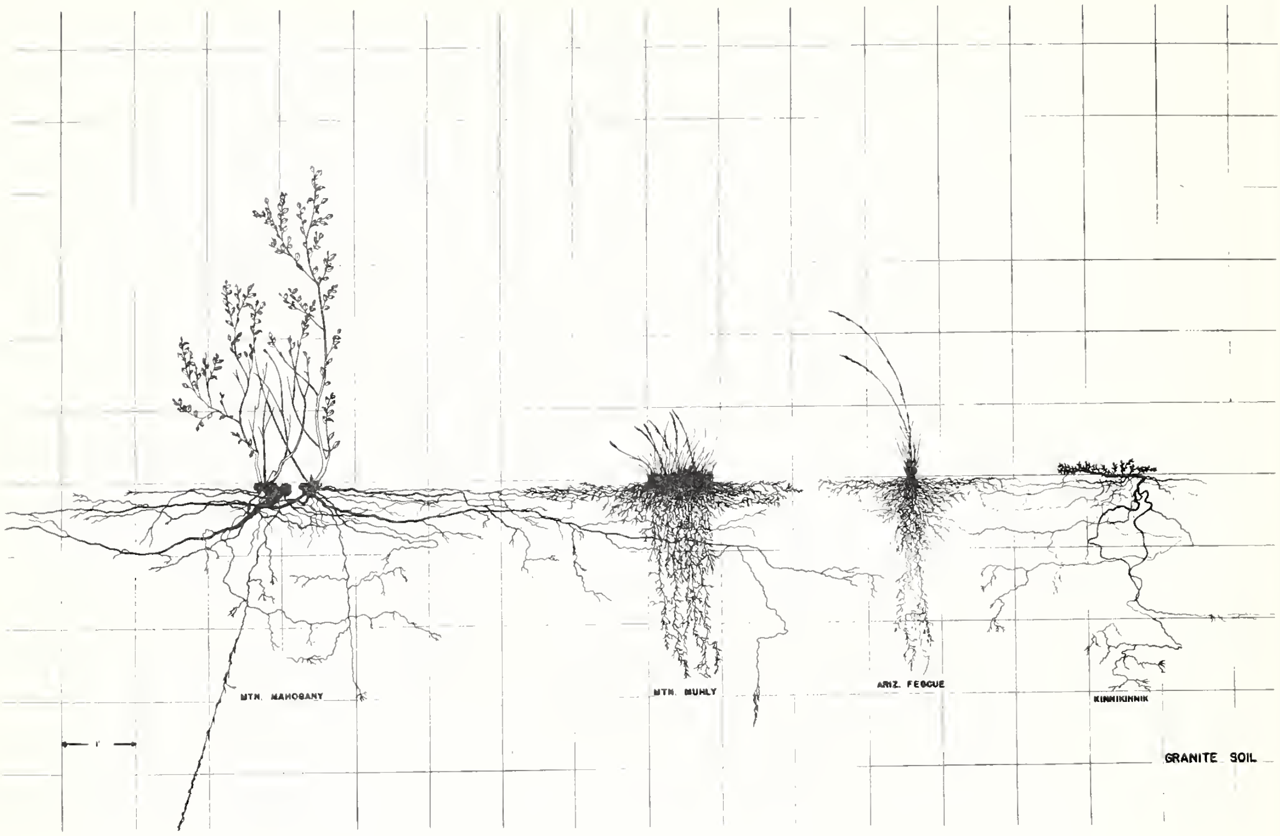


Figure W-9.--Examples of roots of mountain-mahogany, kinnikinnik, mountain muhly, and Arizona fescue as they grow in open forest stands on granite soils at Manitou Experimental Forest. Mountain-mahogany had some roots as deep as the overstory trees but the other species extended to only 3 feet. The mountain muhly clump was 10 inches in diameter, and 316 separate roots originated at its base. The fescue clump was 4 inches in diameter and had 290 roots. These grass roots form a much denser network than those of trees or shrubs.

rainfall during the period. Included are all losses from interception, evaporation, and transpiration. The study plots were thinned in 1957 to determine how this practice changes moisture use (fig. W-10).

Figure W-10. --These Black Hills ponderosa pines used one-third inch of water per day during a 2-week period of abundant moisture in June 1957. The stand had 2,885 trees per acre, with an average d.b.h. of 3.3 inches and a total basal area of 171 square feet per acre. Last summer this stand was thinned to 435 trees with a basal area of 80 square feet per acre. The effect of this thinning on water use will be determined.

No change in streamflow after selective cutting

During the 1957 water year, streamflow from the South Fork of Workman Creek at Sierra Ancha Experimental Forest, Arizona, was in line with that predicted had no trees been cut. Between 1953 and 1956, 36 percent of the original basal area of trees was cut by a selection system designed to favor growth of high quality ponderosa pine (fig. W-11). It is, of course, too early to make definite statements about the long-term effect of this kind of cutting on water yields. Although precipitation was more favorable than in 1956, it was insufficient to satisfy the soil-moisture deficit accumulated during previous drought years. True indications of the effect of treatment will require enough moisture to prime the deep soils of this watershed. It is possible that remaining vegetation is sufficient to use as much moisture as the original stand even in wet years, but this cannot be definitely known until there are more years of record.

Figure W-11. --Pine-fir type on the South Fork of Workman Creek in Arizona before selective cutting. Thirty-six percent of the original forest was cut between 1953 and 1956. Streamflow has shown no change, perhaps because of drought conditions or because of higher moisture use by remaining vegetation.

A forest fire swept in from outside the experimental forest and burned 60 acres of the 320-acre study watershed. A large proportion of trees left after cutting were killed. More definite mortality figures cannot be obtained until 1958. The burned area was seeded to grass, but torrential rain washed away much of the seed.

Sediment movement after wildfire

The fire discussed above was followed by one of the hardest summer rainstorms in 20 years of measurement. Total rainfall was 3.50 to 4.05 inches, with about 2 inches of this falling in 30 minutes. This storm washed most of the ashes and much soil from the burned area. The average soil loss was a 0.2-inch-thick layer or a total volume of about 1 acre-foot of soil from the 60 acres burned. Two percent of the soil moved off the burn was deposited in the weir pond, 40 percent in the channel, 46 percent in depressions outside the burn, and 12 percent could not be traced (fig. W-12).

Pilot action program in Arizona

Tests of large-scale thinning of ponderosa pine stands and clearing of juniper trees are in full swing on the Beaver Creek drainage of the Coconino National Forest. Precipitation and streamflow measurements will help evaluate results. The year 1957 was an extremely wet one in the project area, with 43 inches recorded in the ponderosa pine type near Stoneman Lake at 7,500 feet elevation. At 6,500 feet in the alligator juniper type, the rainfall was 32 inches, and in the Utah juniper at 5,500 feet there was 27 inches of rain.

A part of the study program is careful measurement of streamflow on watersheds with uniform plant cover. Twelve watersheds ranging from 160 to 3,000 acres are serving as "guinea pigs." Measurement of the flash flows typical of woodland areas is a difficult problem. Streams peak rapidly and carry large boulders, logs, and other debris. A flume designed for these conditions was developed in cooperation with Colorado State University (fig. W-13). The wet season gave a quick and thorough test to these devices, and they do the job (figs. W-14, W-15, and W-16).

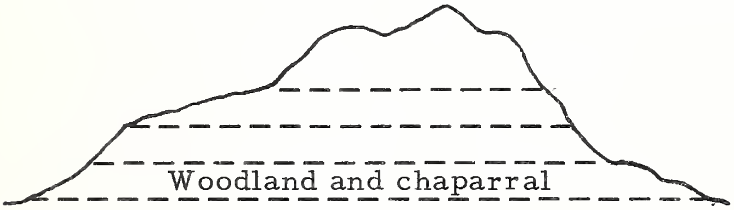
Figure W-12. --Forest fire followed by torrential rain did this on 60 acres of the South Fork study watershed in Arizona. One and one-quarter inches of organic material were burned and washed away plus 0.2 inch of the soil itself. One acre-foot of soil was carried off the burned area, of which 42 percent was deposited in the stream channel within one-half mile of the burn.

Figure W-13. --A view of the flume used to measure streams at Beaver Creek. The total length is 15 feet and side walls are 4 feet high with a slope of 30°. The intake end of the floor is 5 feet wide, and the narrow part is 1 foot wide. This flume was designed to measure a wide range in streamflow and to let rock and debris slide through.

Figure W-14. --A view upstream from one of the Beaver Creek stream gages. Steep rocky stream channels characterize watercourses on their way down from Mogollon Rim.

Figure W-15. --Five minutes after figure W-14 was taken. Here is the flood wave arriving after a downpour of 2.5 inches hit part of the 1,800-acre watershed. Quick rises, high flood peaks, and large debris loads complicate measurements of streamflows.

Figure W-16.--Here is the flume in high water. One minute after this picture was taken the treetop had passed through the flume. The top was 24 feet long and 28 inches in diameter.



At the lower edge of the commercial timber zone, small trees and shrubs are an important part of the plant cover. How to decrease density of this cover and increase the amount of grass and palatable browse species is an important problem in livestock and game production. The effect of plant cover upon water yield is also important. Even though per-acre water yields are low, the enormous number of acres would make even small increases important. This zone is also one of torrential storms; hence, control of erosion and flood peaks is important to areas downstream.

Great variation in rainfall and runoff in New Mexico

The recent demand for watershed treatments to increase water yields in the Southwest points to the need for more basic information on precipitation and runoff. Until we have more information on expected variations and a better understanding of the causes involved we cannot fully interpret our research findings or adequately develop the guides for watershed management. By way of simple example: Suppose we have two adjacent watersheds, one treated to increase water yield, the other undisturbed. A passing storm drops 2 inches of rain on the treated watershed, resulting in high runoff; but on the undisturbed watershed there was only one-half inch of rain and low runoff. Without knowledge of rainfall distribution from that storm one could not possibly hope to interpret the runoff measurements properly.

On the San Luis experimental watersheds in central New Mexico a precipitation gaging network to measure these variations in rainfall has been in operation for 5 years. An example of rainfall variation from one place to another during one storm (October 19-21, 1957) is shown in figure W-17.

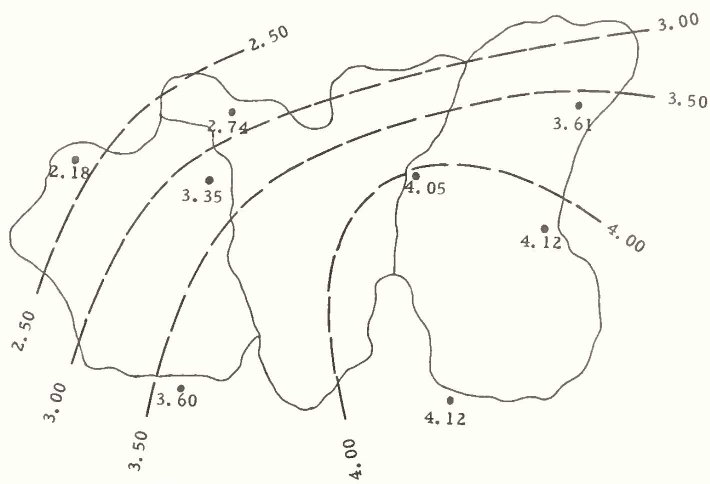


Figure W-17.--Rainfall from this storm varied 2 inches in total amount in a distance of 2 miles. The figure shows the three San Luis watersheds on the Rio Puerco drainage of New Mexico. Also shown are rain gage readings and lines of equal rainfall. Annual rainfall in 1957 varied from 11 inches to more than 13.5 inches. The total for 1956 was between 2 and 3.5 inches. Extreme variability of precipitation from year to year makes restoration of plant cover difficult.

The variation in precipitation, runoff, and sediment moved off the San Luis watersheds is given in table W-1. Runoff has been measured only between June and mid-November. About two-thirds of the annual precipitation is received during this period. Winter precipitation is almost entirely snow, which melts so slowly that there is no surface runoff.

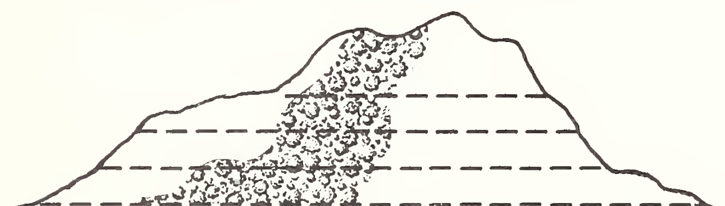
Table W-1.--Annual precipitation, runoff, and sediment production by watersheds at San Luis experimental watersheds

Year	Watershed	Annual precipitation	Annual runoff	Annual sediment production
	No.	Acre-feet per square mile		
1953	I	---	0.09	0.05
	II	---	1.41	0
	III	---	6.23	.58
1954	I	644.3	18.08	.47
	II	685.5	21.22	1.34
	III	706.1	49.85	.19
1955	I	505.2	32.84	.99
	II	619.7	26.83	.52
	III	618.1	22.67	.64
1956	I	173.5	6.46	.56
	II	163.1	10.87	1.01
	III	135.8	6.16	.77

The study at San Luis is in cooperation with Mr. Cass Goodner, and the Bureau of Land Management and Geological Survey of the U. S. Department of the Interior. The object is to demonstrate the effect of grazing practices and land treatment upon runoff and erosion.

Figure W-18.--Chaparral in Arizona covers many acres. Most abundant plants are scrub live oak, manzanita, mountain-mahogany, silktassel, skunkbush sumac, and ceanothus. Research in this type was strengthened in 1957. Methods for controlling unwanted species and the effect of changes in plant composition and density are under study. Watersheds have been selected to serve as test areas for control methods.

Streambank and flood plain zone



Streambank and flood plain vegetation

In all elevation zones, vegetation in the wet areas of the flood plain and along the streambanks is different from that on the hillsides. Lush water-loving plants growing in the wet areas have unlimited opportunity to obtain moisture. The question here is how can this vegetation be altered to (1) use less water or

(2) provide more useful products. A first step is to find out how much water these species do use. A special transpiration-measuring apparatus is being developed to measure water use in the field (fig. W-19). Another step is to study the development of plants from seed to maturity to aid in control of those undesired as well as establishment of more desirable species.

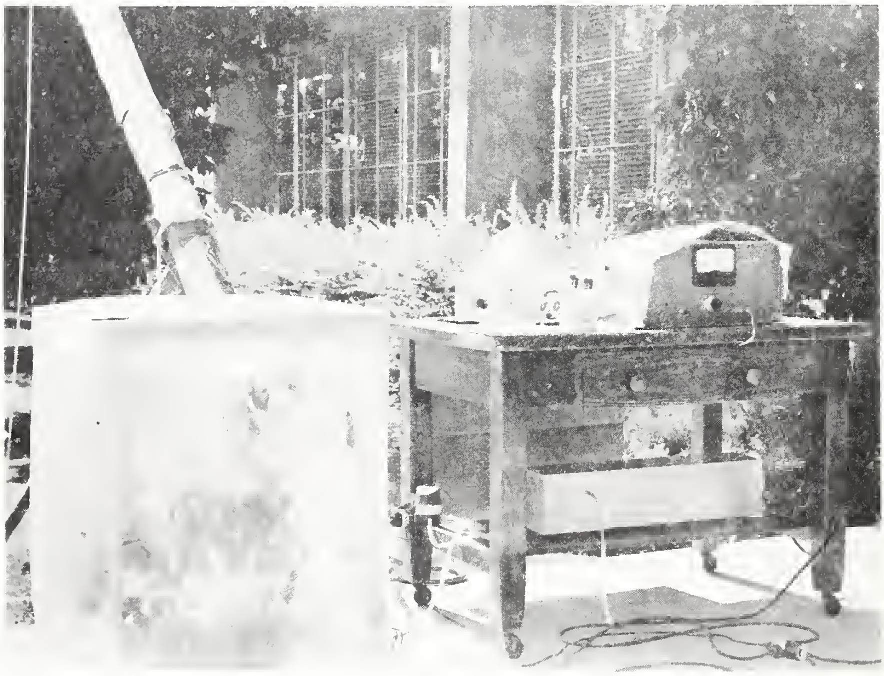


Figure W-19. --Early model of a field-going portable transpiration-measuring device. The polyethylene tent is set over a bush to measure water vapor given off by the plant. The duct in the background leads in outside air. Humidity of inflowing and outflowing air is measured by an infrared gas analyzer. The difference in humidity multiplied by rate of ventilation measures moisture lost by the plant and soil enclosed. A larger model with a tent 6 x 6 x 8 feet was field tested in 1957. Even larger enclosures will be used in 1958.

Tamarisk (salt-cedar) has received most attention because of its abundance and rapid spread into new areas. The knowledge gained about seedling establishment points to possible control measures and indicates sites favorable for seedling establishment.

1. Tamarisk seeds are produced almost continuously from April to September. Because they are light, they are dispersed widely by wind. Seeds also float and germinate in water, and seedlings may become established when stranded by receding water.

2. Seeds germinate only in water, on continuously wet soil, or in 100-percent humidity on moist surfaces.

3. Although germination is rapid, seedlings become established slowly. For a week or more after germination the seedlings can obtain moisture only from saturated soil. During this time, drought will kill seedlings or high water will float them loose.

4. Seedlings do not develop when air temperature is less than 82° F.

FOREST MANAGEMENT RESEARCH

Forest management research develops information needed to improve forests in the central and southern Rocky Mountains and tree plantings in the Great Plains.

Highlights of research in forest management for the year follow.

Artificial regeneration tried in beetle-killed spruce stands

Planting proved more successful than seeding for getting Engelmann spruce and lodgepole pines started where beetles have killed the seed trees. Practically all nursery trees of both lodgepole pine and Engelmann spruce survived the first growing season. Overwinter losses have not yet been measured.

Seeding was more successful for lodgepole pine than for spruce. More than half of the pine seeds germinated, but only one-tenth of the spruce seeds germinated. Approximately one-half of the lodgepole pine and more than four-fifths of the spruce seedlings that germinated died by fall. Damping-off was the greatest cause of loss (table F-1).

Shading and mulching had no effect on survival of either planted or seeded seedlings (fig. F-1). Any effect the treatments might have had on drought losses were nullified by the extremely wet growing season.

Moderate to light windfall followed clearcutting in spruce-fir

Windfall along cutting borders was studied in Colorado on five representative sale areas where Engelmann spruce—subalpine fir had been clear cut. Sale areas examined were on Silver Creek, Red Sandstone Creek, and Middle Creek on the White River National Forest; Supply Creek on the Arapaho; and East Fork of Willow Creek on the Routt (table F-2).

Table F-1.--Mortality of seedlings by causes, White River Plateau, Colorado, 1957

Cause of mortality	Treatment				Total	Total losses
	Shade	Mulch	Shade and mulch	None		
	No. trees					Pct.
	Lodgepole pine					
Damping-off	151	211	203	157	722	28
Other diseases 1/	14	92	31	144	281	11
Missing 2/	97	136	142	72	447	17
Unknown	66	86	62	102	316	12
Heat	80	68	46	110	304	12
Trampled 3/	34	37	20	92	183	7
Clipped 4/	48	36	33	42	159	6
Insects	20	14	8	28	70	3
Gophers	27	0	6	5	38	2
Other 5/	14	5	13	4	36	2
Total	551	685	564	756	2,556	100
	Engelmann spruce					
Damping-off	119	158	84	130	491	62
Missing 2/	24	30	16	20	90	11
Unknown	7	19	13	7	46	6
Heat	12	25	13	23	73	9
Trampled 3/	6	15	9	22	52	6
Clipped 4/	7	7	10	1	25	3
Other 5/	2	5	1	7	15	3
Total	177	259	146	210	792	100

1/ Mainly root rots after the seedlings had hardened.
2/ Seedlings could not be found.
3/ Trampled by sheep, deer, and people.
4/ Caused by rodents or birds.
5/ Frost heaving, hail, and accidental pulling; for Engelmann spruce, the figures include other diseases, insects, and gophers.

Figure F-1. --Survival of Engelmann spruce and lodgepole pine seedlings in seed spots treated in four ways is being studied in this experimental block: Left, shaded and mulched; left center, shaded; right center, mulched; foreground, neither shaded nor mulched.

Study of these five areas has revealed no distinct relations that might be used to reduce future losses. Average losses have ranged from 0.5 tree to 8 trees and from 43 to 794 board-feet to the acre. Most of the windthrows were felled by westerly winds. More than two-thirds fell in the northeast, east, and southeast quadrants. No consistent relationship between amount of windfall and position on the slope was found. Less than half of the felled trees were defective. Losses have diminished with time since cutting; more trees blew down within 2 years after cutting than later.

Table F-2. --Summary of windfall losses after clearcutting spruce-fir on five sale areas in Colorado

Location of sale area and cutting treatment	Years cut	Units cut	Aspect	Relation to prevailing winds	Slope	Windfalls	Volume	Primary direction of fall	Windfalls		
									1957	1955 - 56	1954 and earlier
		No.			Pct.	No./acre	Bd.ft./acre		- - - -	No.	- - - -
White River National Forest											
Silver Creek											
Vertical strips	1952-53	14	N to NW	Windward	5 to 40	6.5	794	E-NE	3	13	8
Blocks	1952-53	10	N to NW	Windward	5 to 40	2.0	294	E-SE	24	86	141
Red Sandstone Creek											
Vertical strips	1952-53	14	N to NW	Windward	5 to 40	2.5	314	S-SE-E	2	5	46
Contour strips	1952-53	2	N to NW	Windward	5 to 40	4.5	374	E-SE	3	70	31
Middle Creek											
Contour strips	1953-54	10	SW & E	Windward & leeward	5 to 20	1.0	86	NE-E-SE	10	10	8
Arapaho National Forest											
Supply Creek											
Vertical strips											
S slope	1951-55	7	S	Leeward	5 to 60	4.0	394	NE-E-SE	20	19	81
NE slope	1951-55	8	NE	Leeward	5 to 60	8.0	600	NE-E-SE	24	19	137
Routt National Forest											
Willow Creek											
Contour strips	1955	6	NE to NW	Windward & leeward	5 to 20	0.5	43	NE-E	8	17	---

Natural thinning is slow for ponderosa pine in the Black Hills

A dense stand of unthinned ponderosa pine reproduction in the Black Hills had not outgrown stagnation in 63 years. The trees are still too small for posts or pulpwood (fig. F-2). Trees of the same age in an adjacent thinned area are large enough for commercial thinning (fig. F-3).

Figure F-2. --This unthinned, stagnated stand has 5,827 living ponderosa pine trees to the acre at 63 years of age. None of the trees are large enough for pulpwood.

Figure F-3.--These 63-year-old ponderosa pines were thinned to 379 trees to the acre in 1934. The stand now contains 16 rough cords of pulpwood to the acre.

Although thousands of trees have died on the unthinned plots, too many still remain to permit reasonable growth of individual trees. Basal areas of the unthinned plots are also excessive (table F-3).

Diameters and pulpwood volumes in 1957 show how growth of individual trees on unthinned plots has lagged behind growth on thinned plots (table F-4).

Two points important to forest managers in the Black Hills are emphasized by these results: (1) Dense ponderosa pine stands must be thinned to avoid a wait of more than 60 years for merchantable material; (2) the growth of stagnated stands as old as 40 years can be accelerated greatly by thinning.

Table F-3. --Numbers of trees and basal areas on unthinned and thinned plots

Plots	Trees per acre			Basal area
	1906	1919	1957	1957
	- - - - No. - - - -			Sq. ft.
Unthinned A	46,310	34,480	5,827	205
Unthinned B	16,000	17,470	6,596	207
Thinned to 4'x4' in 1919	---	3,280	2,220	173
Thinned to 10.3'x10.3' in 1934	---	---	379	88

Table F-4. --Comparison of diameters and pulpwood volumes on thinned and unthinned plots in 1957

Plots	Average d.b.h.		Pulpwood per acre
	All trees	100 largest trees per acre	
	- - Inches - -		Cords
Unthinned A	2.5	4.0	0
Unthinned B	2.4	4.2	0.5
Thinned to 4'x4' in 1919	3.8	5.8	1.5
Thinned to 10.3'x10.3' in 1934	6.5	8.1	16.1

Success of direct seeding of ponderosa pine depends on moisture

Reasons for success or failure of 143 direct seedings of ponderosa pine made from 1905 to 1953 in the Black Hills have been investigated.

Available soil moisture proved to be the key to success (fig. F-4). More seedings were successful (1) in wet years than in dry years, (2) on gentle than on steep slopes, (3) on lower slopes than on higher slopes, (4) on north and east than on south and west exposures, and (5) where competition from other vegetation was light.

On southerly and westerly exposures, best results were obtained near the base of slopes where the grade was less than 30 percent. On other exposures well-stocked stands were often obtained on higher and steeper slopes.

Seedings made in grass sod or under dense stands of aspen, white birch, or bur oak usually failed. In one area that supported an 11- to 14-year-old cover of grass and forbs, however, fully stocked stands were obtained by broadcast seeding in 4 years of well-above-average precipitation.

Soil erosion and washing of pine seed also caused failures. Soils from limestones eroded and washed on some slopes as gentle as 12 percent. Washing and erosion of soils from schists and shales, however, were observed only on slopes of 20 percent or more. Records show that greatest seed losses from erosion occurred where seeding was done the first year after a fire.

Of the 143 seedings examined, 39 (1,824 acres) were at least 60 percent stocked; 38 (8,434 acres) were 10 to 60 percent stocked; and 66 (5,675 acres) were less than 10 percent stocked. Where trees were less than 6 feet tall, the percentage of 6.6'x6.6' plots having one or more trees was used to rate stocking. For larger trees, stocking was determined by estimating the percentage of area being utilized by ponderosa pine.

Figure F-4. --This section of the McVey Burn of 1939 in the Black Hills was broadcast seeded with 7.6 pounds of ponderosa pine seed to the acre in March 1941. Stocking now averages 70 percent on 1,171 acres.

Leachings from certain litter damage ponderosa pine seed

During the winter of 1956-57, six small lots of ponderosa pine seed were overwintered in the open on the Fort Valley Experimental Forest, Arizona. Four of the screen-protected storage spots were covered with juniper litter, oak litter, pine litter, and Arizona fescue, respectively, and two spots had no cover. The seeds were removed before the summer rains began in July 1957 and were germinated in vermiculite (table F-5).

These results suggest that the coverings of juniper and Arizona fescue litter had a detrimental effect on germination of ponderosa pine seed.

Table F-5.--Influence of leachings from different litters on germination of ponderosa pine seed

Overwinter treatment	Seeds in lot	Seeds germinated	Germination
	No.	No.	Pct.
Juniper litter	370	205	55
Arizona fescue litter	400	253	63
Oak litter	400	336	84
Needle litter	400	339	85
No cover (spot 1)	350	295	84
No cover (spot 2)	210	190	90

Shade and moisture affect ponderosa pine seeding

The effects of shade and moisture on the success of direct seeding ponderosa pine were tested on four blocks on a 7-year-old burn in Arizona. Each block was divided into three plots and each plot received a different "moisture" treatment:

1. Natural ground conditions, vegetation undisturbed.

2. Vegetation removed by scalping.

3. Natural ground conditions, but watered to eliminate effects of short periods of summer drought.

Each plot was divided into three subplots, one each of which received full shade, part shade, and no shade, respectively.

Total germination of seeds between August 2 (when the first seedlings broke the surface) and September 12 was significantly better under partial and no shade than under full shade (table F-6). The ground may have remained too cold under full shade. For the moisture treatments, germination was better on watered and scalped plots than on natural plots, but the differences were not great enough to be significant statistically. Because the summer was exceptionally wet, the differences between moisture treatments were undoubtedly less than they would be during a drier season.

Table F-6.--Total germination of ponderosa pine seeds in relation to shade and moisture, expressed as percentage of seed sown

Moisture treatments	Shade treatments: Full	Partial	None	Average
	Percent			
Natural	15.9	21.7	21.7	19.8
Scalped	23.6	26.7	24.8	25.0
Watered	16.0	25.7	25.6	22.4
Average	18.5	24.7	24.0	22.4

Of the 2,419 seedlings that germinated by September 12, more than one-third (877) had died by October 31. Sixty-seven percent of all losses were attributed to drought, mostly during the dry, windy month of September. Thirteen percent died of what appeared to be a fungus disease during the cold, wet, last half of October. Nine percent were killed by rodents or birds, and 11 percent died from other causes.

Drought losses were significantly greater on the unshaded than on the full or partially shaded plots. Differences between the moisture treatments were not significant (table F-7). The small role played by the moisture treatments was likely due to the exceptionally wet summer.

Table F-7.--Total drought mortality up to October 31 in relation to moisture and shade treatments expressed as percentage of total seeds that germinated

Moisture treatments	Shade treatments: Full	Partial	None	Average
	Percent			
Natural	35.1	20.4	53.5	36.4
Scalped	22.3	11.6	43.3	25.4
Watered	15.6	8.4	29.0	18.0
Average	24.0	13.1	41.3	26.2

The number of seedlings surviving on October 31 was significantly greater under partial shade than under full or no shade (table F-8). More surviving seedlings were found on the scalped plots than on the watered, and more on the watered than on the natural. None of the differences between moisture treatments were significant, however.

Table F-8.--Seedlings surviving on October 31 in relation to moisture and shade treatments

Moisture treatments	Shade treatments			Total
	Full	Partial	None	
	- - - - - - Number - - - - - -			
Natural	99	169	103	371
Scalped	186	273	152	611
Watered	129	239	192	560
Total	414	681	447	1,542

For the wet summer of 1957, partial shade was the most effective treatment for aiding establishment of ponderosa pine by spot seeding. Removal of vegetation helped, but not significantly.

Aspen sprouts should be protected from browsing

A study started in 1949 near Flagstaff, Arizona, shows that young aspen suckers should be protected from livestock browsing.

The study area was logged for excelsior wood in the spring of 1949. Treatments were applied to each of three blocks the same year:

1. Check -- no treatment
2. Summer treatments -- cut all residual trees
   girdle all residual trees
   poison all residual trees with "ammate"
3. Fall treatments -- cut all residual trees
   girdle all residual trees

The number of root suckers counted in 1951 and 1956 did not differ significantly between treatments (table F-9) nor was there any relation between number of suckers and original stand, stand cut, or residual stand.

Table F-9.--Number of aspen suckers following treatment of residual stand

Treatment of residual stand	Suckers per acre	
	1951	1956
	No.	No.
Check (no treatment)	15,900	3,900
Summer treatments:		
Cut	22,400	3,200
Girdle	12,600	1,800
Poison	18,100	1,000
Fall treatments:		
Cut	19,100	4,800
Girdle	14,200	3,600

In 1951, one of the three blocks was fenced against cattle and sheep, but not against deer. Numbers of surviving suckers and heights of dominants were both significantly better on the fenced block than on the two unfenced blocks in 1956 (table F-10).

Table F-10.--Survival and height growth of aspen suckers in relation to fencing

Block	Suckers per acre		Average height of dominant suckers in 1956
	1951	1956	
	No.	No.	Inches
B (fenced)	12,400	6,700	134
A (unfenced)	14,600	900	106
C (unfenced)	24,300	1,600	65

Suckers surviving on the two unfenced blocks were very irregularly spaced; 4 of the 12 plots had no survivors in 1956.

Supplemental light hastens production of nursery stock

Three tests of the influence of supplemental light on the growth of seedlings are now underway at Lincoln and at Bessey Nursery, Nebraska.

Test A

One-year-old seedlings of ponderosa pine and eastern redcedar and seed of Austrian pines were placed in pots in December 1955 and subjected to 4 light treatments in a greenhouse until March 1956 (14 weeks). The treatments were:

1. Fourteen hours' continuous light;
2. Fourteen hours plus 2 hours starting at midnight;
3. Fourteen hours plus additional light from 10 p.m. to 11 p.m. and 2 a.m. to 3 a.m.
4. Continuous light.

The same treatments were repeated out-of-doors from April to October 1956 (24 weeks). The lights were then turned off and the trees left out-of-doors overwinter. They were removed from the pots, field planted in the spring of 1957, and checked for survival in November 1957 (table F-11).

Test B

Potted seedlings of ponderosa and Austrian pines, produced from seed in the spring of 1956 were subjected to the same 4 light treatments as the trees in test A. The treatments, continuous except for a 2-month break in the fall of 1956, extended for 86 weeks: 24 weeks outside (May to October 1956); 21 weeks in a greenhouse (December to May 1957); and another 21 weeks outside (June to October 1957) (table F-12).

Table F-11.--Response of 3 species of conifers to 4 light schedules through 2 growing periods, and field survival after 1 season under natural conditions (Test A)

Treatment	Trees treated	Initial height before treatment	End of light treatments: Height	End of light treatments: Green weight	End of light treatments: Top-root ratio	Field survival
	No.	cm.	cm.	gm.		pct.
Ponderosa pine (1-0)						
14 hrs. continuous light	15	7.1	10.3	24.8	1.0	93
14 hrs. light + 2 hrs. starting at midnight	13	7.2	12.5	23.4	1.4	85
14 hrs. light + 1 hr. 10-11 p.m. + 1 hr. 2-3 a.m.	14	7.2	14.0	32.9	1.2	93
Continuous light	15	7.9	19.7	43.1	1.4	100
Austrian pine (from seed)						
14 hrs. continuous light	15	seed	3.4	14.2	0.6	93
14 hrs. light + 2 hrs. starting at midnight	16	seed	4.8	17.4	1.1	88
14 hrs. light + 1 hr. 10-11 p.m. + 1 hr. 2-3 a.m.	16	seed	3.7	12.8	1.1	81
Continuous light	16	seed	6.1	22.6	1.1	88
Eastern redcedar (1-0)						
14 hrs. continuous light	16	11.6	26.3	60.6	0.7	100
14 hrs. light + 2 hrs. starting at midnight	17	11.9	31.7	59.7	1.0	100
14 hrs. light + 1 hr. 10-11 p.m. + 1 hr. 2-3 a.m.	16	11.6	32.3	68.4	.9	100
Continuous light	17	12.4	35.5	96.0	1.1	100

Table F-12.--Response of 2 species of conifers to 4 light schedules through 3 growing periods (Test B)

Treatment	Trees treated	Weight October 1956	Height October 1956	Height May 1957	Height October 1957
	No.	gm.	cm.	cm.	cm.
Ponderosa pine (from seed)					
14 hrs. continuous light	24	4.5	3.7	7.0	12.0
14 hrs. light + 2 hrs. starting at midnight	24	4.6	3.7	8.6	14.0
14 hrs. light + 1 hr. 10-11 p.m. + 1 hr. 2-3 a.m.	23	4.6	3.9	9.1	14.2
Continuous light	24	5.7	4.2	10.4	15.5
Austrian pine (from seed)					
14 hrs. continuous light	23	5.2	3.2	5.4	10.4
14 hrs. light + 2 hrs. starting at midnight	24	5.7	2.7	7.6	9.8
14 hrs. light + 1 hr. 10-11 p.m. + 1 hr. 2-3 a.m.	23	5.9	3.1	7.7	9.1
Continuous light	25	6.2	3.3	7.6	9.2

Table F-13.--Response of ponderosa pine and eastern redcedar in Bessey Nursery beds to 3 light treatments from July 12 to October 20, 1957 (Test C)

Treatment	Ponderosa pine seedlings (germinated spring 1957): Sample trees	Ponderosa pine seedlings (germinated spring 1957): Average height	Eastern redcedar seedlings (germinated spring 1957): Sample trees	Eastern redcedar seedlings (germinated spring 1957): Average height	1-1 eastern redcedar transplants: Sample trees	1-1 eastern redcedar transplants: Average height
	No.	cm.	No.	cm.	No.	cm.
Normal day length	145	3.94	280	5.12	775	16.59
20 hrs. continuous light	170	5.31	170	6.14	339	18.78
Continuous light	130	5.91	100	6.02	300	17.92

Test C

Parts of regular nursery beds at the Bessey Nursery in Nebraska were subjected to three light treatments from July 12 to October 20, 1957. The treatments were:

1. Normal day length;

2. Twenty hours' continuous light daily;

3. Twenty-four hours' continuous light daily.

The seedlings treated included ponderosa pine and eastern redcedar that had germinated in the spring of 1957, and 1-1 eastern redcedar transplants (table F-13).

Height growth of ponderosa pine and eastern redcedar was stimulated in all tests (figs. F-5 and F-6). Growth was better under continuous light than under all other treatments except for the 20 hours' continuous daily light at the nursery. Test C at the nursery lasted only 14 weeks but growth has been best so far under the 20-hour daily schedule (table F-13).

Height growth of Austrian pine was also best under continuous light in test A (table F-11) and for the first 2 periods of supplemental light in test B (table F-12). But during the last 21-week period the seedlings under normal day length grew nearly twice as much as any that received supplemental light, and more than 3 times as much as those under continuous light. Austrian pine may need periodic rests.

The larger seedlings produced under supplemental light weighed more than the smaller seedlings grown with no supplemental light. Apparently the supplemental light stimulated more top growth than root growth. The top-root ratio was higher in all cases for seedlings grown under supplemental light (tables F-11 and F-12).

Supplemental light did not reduce first-year survival when the test A trees were planted in the field (table F-11). Although some differences in survival among treatments were found, they are too small to be considered significant. The fast-grown trees seemed to be as suitable for field planting as the more slowly grown ones.

Supplemental light for Austrian pine apparently should not be continued too late in the fall. The Austrian pine seedlings in test A appeared soft and succulent when the lighting was discontinued in October. Approximately half of the terminal buds were winterkilled.

Figure F-5.--(A) Ponderosa pine seedlings grown under normal day length. (D) Ponderosa pine seedlings that received continuous light for one 14-week and another 24-week period.

Figure F-6.--(A) Eastern redcedar seedlings grown under normal day length. (D) Eastern redcedar seedlings that received continuous light for one 14-week and another 24-week period.

Wind, temperature, and transpiration reduced by windbreaks

Beneficial effects of windbreaks were brought out by a study in cooperation with the Agricultural Research Service, Manhattan, Kansas. Conditions in the lee of a windbreak 25 feet high and 1,200 feet long were compared with conditions in the "open," 450 feet to windward of one end of the windbreak.

Wind velocity was reduced by 50 percent or more for an average distance of 8 tree heights (8H) along the center line in the lee of the windbreak. An average reduction of 30 percent or more was recorded out to 12H, and 20 percent to a distance of 26H.

The pattern of air temperatures in the lee of the windbreak changed with time of day. The pattern seemed to be determined primarily by the turbulence in the air flow that was caused by the windbreak. At midday the air to the leeward was warmer than open air out to about 5 tree heights. Beyond 5H the air was cooler than in the open.

At night, only a thin layer of air in the lee of the windbreak was warmer than in the open. The thin layer extended vertically to the height of the trees at about 1H. Beyond that it extended as a layer only 2 or 3 feet thick along the ground out to beyond 28H.

Transpiration rates in the lee of the windbreak were reduced by 10 percent or more out to a distance beyond 25H. The maximum reduction was 21 percent at 2H.

Red rot increases moisture content of large fuels

Ponderosa pine sapwood containing red rot, caused by *Polyporus anceps*, absorbs more moisture and stays wetter than sound wood for at least 30 days after heavy rains cease. Samples were taken from logging slash left in 1935 on the Fort Valley Experimental Forest in Arizona. Moisture content of sapwood (percent of ovendry weight) from 4 infected and 4 uninfected tops was compared 15 and 30 days after the end of the summer rains.

Difference between the sound and rotted wood were as follows:

	15 days	30 days
Wood with red rot	130%	84%
Wood with no red rot	51%	44%

The 2-index system can cut fire loss

Even during dry years only a few days bring conditions that could touch off a serious forest fire. One of the aims of rating fire danger is to identify those critical days.

In Arizona and New Mexico the 2-index system does this very well. The 2-index system operates like this: one index gages the flammability of high-energy-yielding fuels -- logs, trees, snags, stumps, and deep duff beds -- the fuels that build serious fires when they burn readily. The other index indicates how quickly fires will get big enough to touch off the high-energy fuels. A combination of flammable fuels and rapid-spreading fires is critical.

Only 5 percent of days, or 12 days in an 8-month fire season, on a 5-year average, rate as critical. This number is much smaller than that obtained with the usual single-index systems. But on these critical days, 12 percent of all fires have exceeded 100 acres in size. Those are the expensive and damaging fires. On noncritical days, the fire control organization has been successful in holding 97 percent of the fires to 9 acres or less. None exceeded 100 acres.

The following tabulation shows the distribution of forest fires by size, on critical and noncritical fire days. The data cover several national forests over a 3-year period preceding the advent of the 2-index system.

	Area burned		
	0-9 acres	10-99 acres	100+ acres
	(Percentage of fires)		
Critical fire days	86	2	12
Noncritical fire days	97	3	0

Present fire-control measures are adequate for the non-critical days that make up 95 percent of the season. The big opportunity to cut fire losses lies in reducing the number of fires that exceed 100 acres on critical days.

The 2-index system identifies the critical days, and the fire plan indicates the action needed. Extra effort to prevent fires from starting would be good business on such days. For fires that do start, an airtight first attack is the only successful defense. After a fire begins to roll, reinforcements are not effective. Rapidly spreading fires do not wait for men or machines.

FOREST DISEASE RESEARCH

Heavier rainfall in 1957 caused abundant fruiting of forest fungi throughout the region. Leaf diseases were widespread. The alternate hosts of pine stem rusts, Indian paintbrush and owlclover, were heavily infected in Colorado and Wyoming. The same was true of chickweeds, the alternate host of spruce-fir broom rusts.

Notable accomplishments in research during the year were: (1) the completion of field work on the dwarfmistletoe survey of Arizona and New Mexico, (2) the inception of a lodgepole pine rust study in Colorado and Wyoming, and (3) the beginning of a cull-indicator study of spruce in Colorado.

Dwarfmistletoes

Dwarfmistletoe survey completed in Arizona and New Mexico

All commercial timber areas have been covered on 4 Indian reservations and 12 national forests (fig. D-1). The survey was conducted in two phases, viz., by line plots and by roadside observations. About 3,050 1/4-acre circular plots were measured and more than 3,600 miles of roadside strip were observed. Approximately 90 percent of all sampling was in the ponderosa pine type.

Preliminary analysis shows that dwarfmistletoe was present on 36 percent of the plots in the ponderosa pine type. This indicates that about 2-1/2 million acres of the type are affected. The parasite was present on 48 percent of the plots in the Douglas-fir type. Dwarfmistletoe in ponderosa pine is most widespread on the Lincoln and Apache National Forests and on the Fort Apache Indian Reservation. It was not found on the San Carlos Reservation.

Figure D-2 shows that mortality in the ponderosa pine type is about four times as heavy in dwarfmistletoe-infected areas as in dwarfmistletoe-free areas. In the Douglas-fir type, comparable mortality is about seven times as heavy. Dead trees within one-half chain of all plot lines were tallied in 1957 to check on the reliability of mortality counts on the one-quarter-acre plots. It was found that the plot line figures bear out the plot mortality data.

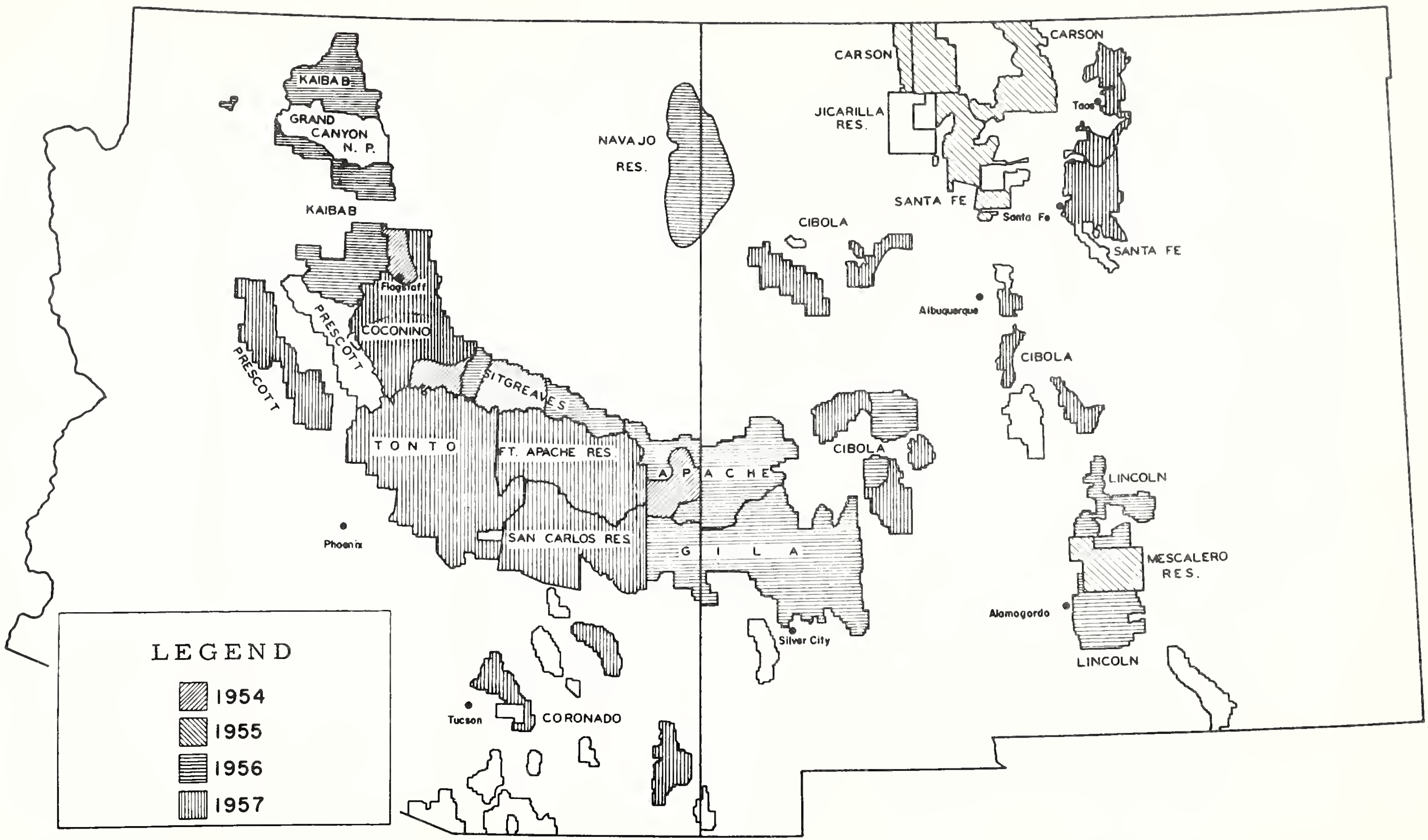


Figure D-1.--Annual progress of dwarfmistletoe survey in Arizona and New Mexico, 1954-57 inclusive.

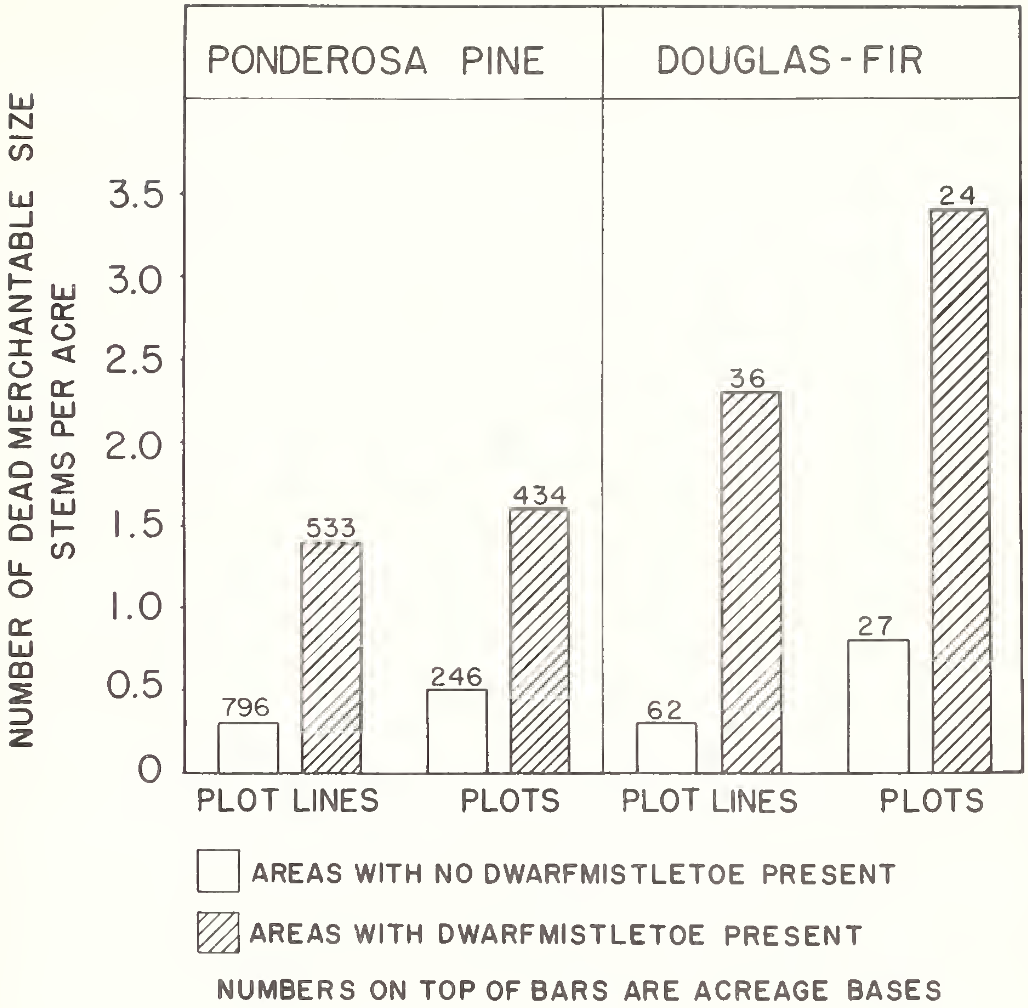


Figure D-2.--Tree mortality as related to dwarfmistletoe in ponderosa pine and Douglas-fir types. Plot data are from 1954-57 survey; plot line data are from 1957 survey only.

Dwarfmistletoe is heaviest on ridge sites and lightest in bottoms, with slope position intermediate. Ridge and bottom sites occupy less than 10 percent of the total forest acreage. Virgin stands had the highest percentage of dwarfmistletoe in merchantable-size stems, and old cutover stands had the lowest. Dwarfmistletoe was more abundant in poles in virgin stands (12 percent of stems) than in either old cutover (6 percent) or recent cutover (8 percent).

New facts from planted dwarfmistletoe seeds

Dwarfmistletoe seeds planted in 1950 show the parasite has a preference for young pine growth. Of the seeds planted on current growth (1950), 9.2 percent developed new dwarfmistletoe plants by 1957; new plants on 1- and 2-year-old growth, respectively, were 6.0 percent and 4.2 percent. Studies in progress will eventually show relative preferences for growth up to 20 years old.

Most of the 1950 seed plantings have now produced shoots; of the total 7-year shoot crop only 3 percent appeared in each of 1956 and 1957. As shown in table D-1, 93 percent of the shoots to date appeared between the third and fifth years after planting.

Table D-1.--Chronology of shoot appearance from dwarfmistletoe seed planted on ponderosa pine in 1950 (Percentages based on total 7-year crop)

Year of observation	Years after planting	Plants producing shoots for the first time	
		Annual	Cumulative
	No.	pct.	pct.
1951	1	0	0
1952	2	1	1
1953	3	25	26
1954	4	32	58
1955	5	36	94
1956	6	3	97
1957	7	3	100

Ballistics of dwarfmistletoe seeds

Measurements of the trajectory of dwarfmistletoe seeds showed a maximum horizontal flight of 42 feet; the average horizontal distance traveled by 110 seeds was 17 feet. Studies thus far suggest that the major thrust is upward and that the height from which seeds are discharged may have little influence on the horizontal distance they will travel.

Heartrots

Study of cull indicators in Engelmann spruce

A preliminary analysis of cull in relation to external indicators on Engelmann spruce shows that more than half of the punk knots, broken tops, wounds, old dead tops, and rust brooms were associated with heartrot. Decay associated with rust brooms was more important in stands 100 to 200 years old (83 percent) than in stands 250 to 550 years old (40 percent). Of 112 trees that sounded solid when struck with an ax, 54 percent contained butt rot; whereas, of 88 trees that sounded rotten when struck, 78 percent contained butt rot.

Losses from hidden red rot offset by cull deductions for visible decay

Red rot was found in 166 logs cut from residual ponderosa pine trees on the Navajo Indian Reservation in Arizona. Commercial cull in these logs amounted to 8,460 board-feet or about 1-1/2 times the actual red rot volume (5,344 board-feet). In terms of the total gross scale of 22,470 feet for the 166 logs, this resulted in a 14 percent overrun. Although 23 (14 percent) of the logs had hidden decay, the decay volume was relatively low (8.4 percent of the gross scale for these logs). Eleven of the logs had decay volumes of 5 board-feet or less, and only two had decay volumes greater than 50 board-feet. In the 143 logs with visible decay, actual decay volumes amounted to 27 percent of the gross log scale; whereas, commercial cull was 46 percent of the scale.

Inoculations with red rot fungus

Results of exploratory work in inoculating living ponderosa pine with the red rot fungus (*Polyporus anceps*) were described in our annual report for 1955 (p. 17). In 1954, 240 additional inoculations were made. Gelatin capsules filled with mycelium and agar from fresh cultures of the fungus were used. The capsules were placed in slits in the bark of dead or dying branches and held in place with adhesive bandage, both with and without cotton poultices. As reported in 1955, there was little or no indication of branch decay from these inoculations in that year. This was also essentially true in 1956. Eight branches were collected at random in 1957 as a further check of the inoculations. There was no sign of decay in four of the branches. Of the remaining four, two showed small pockets of decay at the point of inoculation; whereas, rot in the remaining two had progressed past the point where the branches were pruned flush with the trunks. On one branch, decay had extended 15 inches since 1954.

Other Diseases

Needle cast of ponderosa pine less striking but more widespread in 1957

In 1957, needle cast of ponderosa pine was more widely distributed in Arizona and New Mexico than heretofore noted. Stands with light to pronounced discoloration had an aggregate area of about 270,000 acres on the Prescott, Coconino, Kaibab, Apache, and Gila National Forests, and the Fort Apache, Navajo, and Mescalero-Apache Indian Reservations. In 1956, the disease was recognized on 2,700 acres of the Prescott and known to exist on undetermined acreages of the Coconino. In contrast to its wider occurrence, the intensity of the disease has decreased.

Observations and laboratory studies to determine the fungi associated with needle cast are being made in cooperation with the University of Arizona. A number of different imperfect and ascomycetous fungi are commonly associated with dead and dying needles. The relationship of these fungi to the needle cast disease, however, is not known. Recently, a hypodermataceous-like fungus was found originating beneath the imperfect stage previously reported as resembling *Lecanosticta acicola*. The concolorous blisters, which externally indicate the position of these fructifications, appear to be associated with the disease.

Abnormal mortality in Arizona and New Mexico juniper

Abnormal mortality of juniper has occurred throughout Arizona and New Mexico in recent years. Since 1951, several areas of spot dying have been examined on the Drake Ranger District of the Prescott National Forest and the Kaibab National Forest in Arizona. In 1957, much larger areas of dying juniper were noted. They were particularly conspicuous on the Drake Ranger District beginning in January and February. By early

May affected stands of juniper covered an estimated 12,000 to 15,000 acres. Similar conditions were noted in the Bandelier National Monument in New Mexico.

Affected junipers appear to die from the top down and from the tips in. Some have only half the crowns killed and cease to be conspicuous after the dead foliage has been shed. Isolations from suspected bark lesions in roots made in April 1957 did not yield any recognized pathogens. Subsequent examinations and isolations of affected Utah junipers near Drake revealed the presence of fungi tentatively identified as Rebentischia thujana Feltg., Dermatella deformata (Peck) Seaver, and a number of imperfect fungi. Some of the imperfects are related to known pathogens. Study areas have been established on the Drake District to follow the progress and behavior of the disease in both stands and individual trees, and to determine its direct as well as contributory causes.

Hypoxylon canker found in Arizona

Hypoxylon pruinatum (Klotzsch) Cooke, observed for the first time in Colorado in 1955, was collected on aspen in the Coconino National Forest in Arizona. This fungus causes what is commonly known as the Hypoxylon canker, which is considered to be one of the major diseases of aspen. The disease causes heavy losses in the Lake States.

Favorable moisture conditions increased the fruiting of forest fungi

Moisture conditions prevailing during 1957 favored the fruiting of various fungi. Species that either have not been previously reported or that have not been found previously upon the hosts with which they are now associated were collected. Among these were a powdery mildew and a Tubercularia associated with wilting of boxelder; a Cladosporium hyperparasite of one of Gymnosporangiums attacking Rocky Mountain juniper; a needle-inhabiting Cytospora of white fir; and a Leuco-paxillus, the sporophores of which were prevalent about the stumps of ponderosa pine.

Marssonia leaf spot and Melampsora rust caused severe defoliation of aspen on the Prescott and Coconino National Forests.

Phaeocryptopus (Adelopus) gaumanni was found attacking Douglas-fir on the Mescalero-Apache Reservation.

Stem rusts of lodgepole pine

Three rusts of economic importance in lodgepole pine in Colorado and Wyoming were observed:

1. Western gall rust (Peridermium harknessii)
2. Peridermium stalactiforme
3. Comandra rust (Cronartium comandrae)

Western gall rust was found to be widespread throughout the region, its southern extent being the Spanish Peaks District of the San Isabel National Forest, its northernmost limit being the Tongue District of the Bighorn National Forest. It was found on 8 national forests and on all ranger districts visited except the Clark Fork and Wind River (Shoshone). It was found to be particularly abundant at Doyle Creek (Bighorn), Yankee Hill (Arapaho), and Redfeather (Roosevelt).

Damage to individual trees was in the form of (1) mortality, (2) decreased increment, (3) malformations leading to defect and cull, and (4) changes in wood structure and color leading to degrade. Damage to stands was primarily in the loss of yield and quality; breakage at cankers had an important influence on yield losses. Mortality was not considered a serious menace to stands, since it occurred mostly in the small dense ones and effected what appears to be a beneficial thinning. In one 65-year-old infected stand, 58 percent of the living trees larger than 4 inches d.b.h. were cankered; in another 85-year-old stand, 81 percent of the trees larger than 6 inches d.b.h. were cankered. Both were well stocked but will be subject to heavy cull at cutting. One canker was found that had originated in 1743. It had girdled only two-thirds of the stem circumference in 214 years.

Peridermium stalactiforme was found to be widespread. It causes damaging mortality in the pole sizes because of its relatively rapid girdling action. It appears to be a serious killer.

Cronartium comandrae was observed as a damaging killer on the Tongue and Buffalo Districts (Bighorn) and the Clark Fork District (Shoshone).

FOREST INSECT RESEARCH

Insect-caused timber losses reached an alltime high in New Mexico and Arizona in 1957. They were low in Colorado, Wyoming, and the Black Hills of South Dakota. The heavy losses in the Southwest were largely caused by bark beetles that have been increasing for several years, and apparently associated with the long drought. Salvage logging of the dead timber is being pushed. In the meantime studies are being made of the life history and habits of the beetles in an attempt to learn how to combat them.

Controls developed by research brought improvement in Colorado, Wyoming, and South Dakota. Insects controlled were the Engelmann spruce beetle, Black Hills beetle, and the mountain pine beetle. We are now learning how and when to use natural enemies against the pests.

Further detailed results of insect surveys and research follow.

Insect Surveys

Forest insect conditions in Arizona and New Mexico

Aerial and ground surveys revealed 3, 251, 000 acres of epidemic infestations in 1957 as compared with 1, 565, 000 acres in 1956. Losses caused by bark beetles in 1956 were placed at 610. 5 million board-feet. Spruce budworm and Great Basin tent caterpillar infestations are relatively unchanged. A new heavy infestation of a tussock moth on white fir was observed. In addition, a sawfly on ponderosa pine and a leaf roller on aspen caused noticeable defoliation damage. Figure I-1 shows the amount of damage by major bark beetles in Arizona and New Mexico since 1952.

In 1956, a complex of *Dendroctonus* and *Ips* species were associated in recently killed pine on 1, 711, 400 acres in Arizona and New Mexico. *Ips* species, usually *I. lecontei* Sw., killed the top of the tree and *Dendroctonus* species, usually *D. barberi* Hopk., filled in and killed the lower sections. Other bark beetles

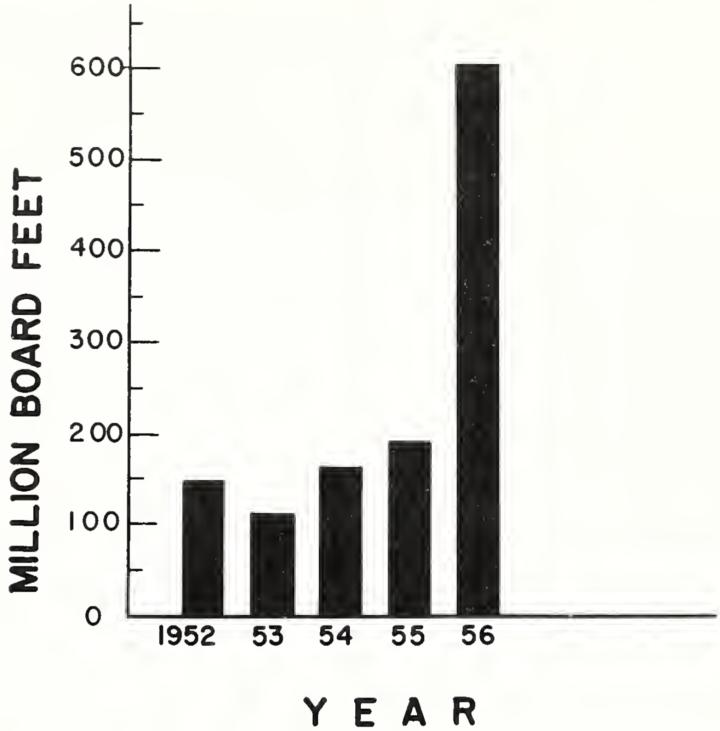


Figure I-1. --Estimated volume of sawtimber killed by major bark beetles in Arizona-New Mexico, 1952-56.

found were: D. convexifrons Hopk., D. approximatus Dietz, and I. ponderosae Sw. Areas suffering severe losses were on the Gila, Cibola, and the Santa Fe National Forests in New Mexico where 344,500, 284,010, and 172,920 areas, respectively, are heavily infested.

Black Hills beetle, Dendroctonus ponderosae Hopk., infestations on the Carson National Forest increased from 10,720 to 18,100 acres. A 100-percent aerial count showed that 450 trees were killed in 1956. The attacks are widely scattered and occur in groups of 2 to 5 trees. The 100-percent aerial count supplemented with a ground check indicates that 500 to 750 infested trees need treatment.

The Black Hills beetle infestation on the Navajo Indian Reservation, active since 1954, was brought under control by direct treatment in 1957. During the 4 years, the Bureau of Indian Affairs treated approximately 1,250 trees with a water emulsion of ethylene dibromide; 60 were treated in 1957.

The outbreak of the roundheaded pine beetle, Dendroctonus convexifrons Hopk. on Mount Graham, Arizona, is still active; 250 infested trees were found on 600 acres. A small localized outbreak in Oak Creek Canyon on the Coconino National Forest was controlled with ethylene dibromide.

Several species of Ips, mainly I. lecontei Sw., caused extensive killing of pinyon and young stands of ponderosa pine (fig. I-2) throughout Arizona and New Mexico. An aerial survey of Ips damage on the South Rim of the Grand Canyon National Park indicated that 3,840 acres were infested. Subnormal rainfall for the past decade has made conditions favorable for an increase of these beetles.

Figure I-2.--Ips have killed young ponderosa pines on the Prescott National Forest, Arizona.

The Douglas-fir beetle, Dendroctonus pseudotsugae Hopk., killed 96 million board-feet of Douglas-fir on 821,200 acres in 1956. The loss was heaviest on the Santa Fe National Forest, with 311,950 infested acres. An increase in tree killing was also recorded on the Jicarilla-Apache Indian Reservation and the Gila National Forest. Much of the area is inaccessible or low in economic value.

The outbreak of the fir engraver beetle, Scolytus ventralis Lec., that started in 1948 continues to damage the white fir stand in the Sandia Mountains east of Albuquerque, New Mexico. Aerial surveys reveal 7,880 infested acres as compared with 6,880 in 1956.

The status of the western balsam bark beetle, Dryocoetes confusus Sw., did not change. Epidemic infestations cover 167,780 acres. Areas on the Santa Fe and the Carson National Forest are heaviest hit.

A small localized outbreak of the Engelmann spruce beetle, Dendroctonus engelmanni Hopk. is active on the Rancho Del Rio Grande Grant, adjacent to the Carson National Forest, near Taos, New Mexico. The buildup was caused by logging practices that left numerous culls and butt logs on the ground.

Spruce budworm, Choristoneura fumiferana (Clem.), infestations caused defoliation on 154,950 acres, a slight decline from 1956. The infestation on the Mescalero Indian Reservation is being checked by natural mortality factors.

In sprayed areas on the Carson and Santa Fe National Forests, light defoliation was observed. Eight years of light to moderate defoliation of mixed conifers on the Kaibab Plateau have caused heavy top-kill of dominant trees and complete destruction of understory in some areas. Heavy moth flight on the plateau was observed.

Two new infestation centers of a needle miner, Recurvaria spp., in ponderosa pine were found. One is near El Rito on the Carson National Forest in New Mexico, and the other is near Williams, Arizona, on the Kaibab National Forest. Both infestations are moderate in intensity. The two infestation centers reported in 1956 are still active; the population increased in the Datil, New Mexico, outbreak and decreased slightly in the Springerville, Arizona, outbreak. The infestations increased from 49,760 acres in 1956 to 111,070 acres in 1957. Damage is limited to previous year's growth. No trees were killed.

An unidentified sawfly has defoliated approximately 600 acres of ponderosa pine south of Grants, New Mexico. Feeding is on old needle growth. The infestation is heavy, but no trees were killed.

An unidentified leaf roller, probably Archips conflictana Wlkr., was numerous on 500 acres of aspen on the Carson National Forest. Past records mention localized defoliation by an aspen leaf roller, which is probably the same insect now active on the Carson National Forest.

Infestations of the Great Basin tent caterpillar, Malacosoma fragile (Stretch) decreased slightly in 1957. Defoliated acreage dropped from 296,600 to 250,690.

A new heavy infestation of a tussock moth, probably Hemerocampa sp., on white fir was observed in the vicinity of Pinal Mountain south of Globe, Arizona. Approximately 100 acres are infested. The top 6 to 10 feet of many of the trees were defoliated, and all crowns show heavy feeding.

A summary of the insect outbreaks is presented in table I-1.

Forest insect conditions in Colorado, Wyoming, and South Dakota

The major forest insect pests are listed in table I-2. Acreages were calculated from aerial work maps. Estimates of volume losses were based on the aerial counts of beetle-killed trees.

Aerial appraisal of bark beetle damage totals 168,800 acres. The estimated volume loss due to bark beetles is nearly 15.5 million board-feet. Of this total, 12.5 million occurs within the 156,840 acres classified as lightly to moderately damaged, much of which, by current standards, would not be subject to control programing.

The gross area of 1957 defoliation as appraised from the air was 318,770 acres. Neither tree mortality nor volume losses were estimated. Damage by the Great Basin tent caterpillar, however, creates much concern, primarily because of its effect on recreation and esthetics.

Although the Engelmann spruce beetle, Dendroctonus engelmanni Hopk., is now endemic, there are two small but important areas where direct control action may be needed. Approximately 20 trees were infested on Red Table Mountain on the White River National Forest. The other infestation is at the head of the Illinois River on the Routt National Forest and contains an estimated 800 trees.

Table I-1. --Summary of forest insect epidemics recorded during the 1957 survey in Arizona and New Mexico

Insect	Arizona		New Mexico		Total	
	Centers	Area	Centers	Area	Centers	Area
	No.	Acres	No.	Acres	No.	Acres
Pine Bark Beetles						
Ips and *Dendroctonus* spp. 1/	92	549,280	121	1,162,120	213	1,711,400
Black Hills beetle	--	--	4	19,380	4	19,380
Roundheaded pine beetle	1	600	--	--	1	600
Arizona five-spined engraver (pinyon pine)	1	2/ 3,840	--	--	1	3,840
Subtotal	94	553,720	125	1,181,500	219	1,735,220
Fir and Spruce Bark Beetles						
Douglas-fir beetle	37	68,590	97	752,610	134	821,200
Fir engraver beetle	--	--	1	7,880	1	7,880
Western balsam bark beetle	5	4,580	27	163,200	32	167,780
Engelmann spruce beetle	--	--	2	1,280	2	1,280
Subtotal	42	73,170	127	924,970	169	998,140
Defoliators						
Spruce budworm	3	74,030	13	80,920	16	154,950
Great Basin tent caterpillar	10	59,680	25	191,010	35	250,690
Aspen leaf roller	--	--	1	500	1	500
Needle miner (ponderosa pine)	1	250	8	110,820	9	111,070
Sawfly (ponderosa pine)	--	--	1	640	1	640
Tussock moth (white fir)	1	100	--	--	1	100
Subtotal	15	134,060	48	383,890	63	517,950
Total	151	760,950	300	2,490,360	451	3,251,310

1/ Arizona five-spined engraver associated with southwestern pine beetle and occasionally one or both of these associated with roundheaded pine beetle, Colorado pine beetle, and western six-spined engraver.

2/ Surveys limited to the infestations at Grand Canyon National Park. Many areas of noncommercial woodland type outside the park are heavily infested.

Table I-2. --Forest insect damage as observed during 1957 aerial survey -- Colorado, Wyoming, and South Dakota

Insect	Centers	Intensity of infestations				
		Light	Moderate	Heavy	Very heavy	Total
	No.	- - - - - - - -	- - - - - - - -	Acres	- - - - - - - -	- - - - - - - -
Bark beetles						
Engelmann spruce beetle	20	1,090	1,010	100	--	2,200
Black Hills beetle	945	52,260	4,340	220	90	56,910
Mountain pine beetle	109	5,860	6,660	260	--	12,780
Douglas-fir beetle	628	9,180	18,730	4,570	380	32,860
Fir engraver beetle	941	25,240	32,470	6,160	180	64,050
Subtotal	2,643	93,630	63,210	11,310	650	168,800
Defoliators						
Spruce budworm	26	83,000	5,610	890	--	89,500
Great Basin tent caterpillar	102	24,710	38,690	68,910	--	132,310
Large aspen tortrix	35	80,100	980	290	--	81,370
Needle miner	1	15,590	--	--	--	15,590
Subtotal	164	203,400	45,280	70,090	--	318,770
Total	2,807	297,030	108,490	81,400	650	487,570

Sampling and observations of spruce trees that were windthrown on the San Juan National Forest in the fall of 1954 were continued. Some of the trees after being down 3 years still provided host material.

Uprooted and broken spruce in a recent blowdown in the vicinity of High Park Lake on the Grand Mesa-Uncompahgre National Forest became infested during the 1957 spruce beetle flight.

Black Hills beetle, Dendroctonus ponderosae Hopk., activity has increased throughout the ponderosa pine type on the eastern slope of Colorado and in the Black Hills of South Dakota. In 1957, 5,212 trees were chemically treated for control; 6,960 trees are scheduled for treatment in 1958.

Increased activity of the Douglas-fir beetle, Dendroctonus pseudotsugae Hopk., has made it a major forest pest. Valuable commercial stands of Douglas-fir as well as the fir on recreational areas and watersheds have suffered considerably. Beetle activity has increased on the San Juan, Grand Mesa-Uncompahgre, Rio Grande, San Isabel, Pike, Roosevelt, and Shoshone National Forests.

The mountain pine beetle, Dendroctonus monticolae Hopk., on the Shoshone National Forest in Wyoming increased. More than 7,400 infested lodgepole pines in epidemic areas on the North Fork of the Shoshone River and its tributaries and on Belknap Creek were chemically treated. A control project to mop up remaining centers of infestation, approximately 4,100 trees, is planned for 1958. An infestation on the Wiggins Creek drainage of the Wind River District is epidemic; 7,500 trees are infested. The major part of this infestation can be controlled through logging.

Western balsam bark beetle, Dryocetes confusus Sw., and fir engraver, Scolytus ventralis Lec., are taking a heavy toll of subalpine fir in Colorado and Wyoming. The low value and inaccessibility of subalpine fir make these losses less serious.

Populations of the Great Basin tent caterpillar, Malacosoma fragile Stretch, in southern Colorado are gradually lessening. A native virus disease is possibly the main cause of mortality.

Approximately 1,600 heavily infested acres in the high-use Cucharas Camp on the San Isabel National Forest were sprayed with DDT by airplane. High mortality of early instar larvae resulted. The egg mass counts late in October showed that very few moths had invaded the sprayed areas from surrounding unsprayed areas.

Damage by the large aspen tortrix, Archips conflictana Wlkr., was classified as light to moderate. Centers of infestation were found on the Grand Mesa-Uncompahgre, Gunnison, and San Juan National Forests. This pest was detected for the first time during the 1956 aerial survey.

Spruce budworm, Choristoneura fumiferana (Clem) infestations are mildly important in the spruce and subalpine fir stands on the San Juan and Rio Grande National Forests. Aerial and ground surveys have failed to uncover an epidemic serious enough to warrant control.

A needle miner, Recurvaria sp., was found on ponderosa pine type near Rye, Colorado, on the San Isabel National Forest and adjacent forest lands. Examination disclosed that 20 to 30 percent of the needles had been mined.

Range Insect Problems

Several new range insect problems were reported and examined. A leaf beetle, *Trirhabda nitidicollis* Lec., defoliated and possibly killed many local areas of rabbitbrush throughout New Mexico. A white grub outbreak on rangeland near Custer, South Dakota, killed most of the grasses on about 6,000 acres, with resultant wind erosion of the soil. The poplar and willow borer, *Cryptorhynchus lapathi* (L.), continues to damage the willow in the Black Hills of South Dakota.

Insect Control

Life history and habits of the southwestern pine beetle

Continued study in New Mexico and Arizona revealed that the southwestern pine beetle, *Dendroctonus barberi* Hopk., attack of ponderosa pine in the fringe type suffering from drought are secondary. The top 15 to 25 feet of trees weakened by drought are infested by *Ips lecontei* Sw. (fig. I-3). Following the *Ips* attack, the southwestern pine beetle infests the remaining lower stem. The flight and attack started 2 to 4 weeks later and ended on September 5 as compared with October 1 in 1956. The number of generations per season is directly related to the prevailing temperatures.

Nematode parasites of bark beetles

Exploration of parasitic nematodes as possible important mortality factors of bark beetles was continued. A new species of *Aphelenchulus* was found in *Ips lecontei* Sw., the bark beetle that has killed extensive stands of pinyon in northern New Mexico. An examination of 256 beetles from 12 trees revealed 56 percent to be infested. Their effect upon egg-laying females was determined by laboratory rearing. Parasitized female beetles laid an average of 16 eggs each in 2 weeks; whereas, nematode-free females laid an average of 32 eggs each. *Ips ponderosa* Sw., a bark beetle that attacks ponderosa pine throughout the Rocky Mountains was found to be commonly parasitized by a similar nematode, probably the same species. *Dendroctonus convexifrons* Hopk., a bark beetle that commonly attacks ponderosa pine in the Southwest was found to be commonly parasitized by an undescribed nematode, *Parasitaphelenchus* sp.

Figure I-3. --Top of ponderosa pine killed by Ips lecontei Sw.

Ponderosa pine can be protected
from bark beetle attack

A virulent outbreak of bark beetles associated with drought has killed much of the ponderosa pine at Bandelier National Monument in New Mexico during the past several years. A pilot test to save some of the remaining green trees was made by the National Park Service. The stems of 745 trees were sprayed with a 2 percent emulsion of DDT prior to beetle flight in the spring. The beetles, largely southwestern pine beetle and the Arizona five-spined engraver, killed only three of the treated trees. They killed 103 of the 286 untreated trees.

Ethylene dibromide effective control of roundheaded pine beetle

In May 1956, a small localized outbreak of the roundheaded pine beetle, *Dendroctonus convexifrons* Hopk., in blackjack ponderosa pine was discovered in Oak Creek Canyon Recreation Area on the Sedonia District of the Coconino National Forest in Arizona. An ethylene dibromide fuel oil solution was applied to 23 trees in June. Formula used was 1 pound of ethylene dibromide in sufficient No. 1 fuel oil to make 5 gallons of solution. The average treating cost was $5 per tree. When the results were checked on July 11, 1956, no live larvae were found. Six newly infested trees were found in the area on April 30, 1957 -- a reduction of 75 percent.

Risk and mortality in ponderosa pine in the Southwest

In 1953 and 1954, forty 10-acre plots were established in ponderosa pine in New Mexico and Arizona. Each tree was assigned to a risk class according to crown vigor and other outward health factors to determine amount of endemic mortality, the responsible factors, and whether high-risk trees could be recognized.

Insects caused 60 percent of the mortality, 10.8 board-feet per acre in 1955 and 22.7 in 1956. Two bark beetles, *Dendroctonus convexifrons* and *D. barberi*, have accounted for most of the mortality. A summary of the total mortality from 1953 to 1956 is as follows:

Risk class	Trees in sample	Dead trees	
	(No.)	(No.)	(Pct.)
4	138	42	30.4
3	576	27	4.7
2	3,013	34	1.1
1	6,010	13	0.2
Total	9,737	116	

Risk-4 trees would isolate 36 percent of the dead in 1 percent of the stand. The inclusion of risk-3 trees would isolate 60 percent of the loss in 7 percent of the stand.

Polyhedrosis virus controls Great Basin tent caterpillar

The success of the introduction of a virus into a virus-free infestation of the Great Basin tent caterpillar on the Navajo Indian Reservation in 1956 became fully evident in 1957. In the area sprayed with a water suspension of the virus, caterpillars died in mass quantities the following summer.

The disease-causing virus carried through the winter as a contaminant on the aspen twigs and in eggs from moths with sub-lethal concentration of the virus. The most effective application period demonstrated to date is from the first opening of the aspen buds to soon after the second molt of the caterpillars. Virus applied to more mature caterpillars does not reach lethal concentrations before the caterpillars pupate. However, progeny from infected parents die the following season. The body contents of diseased caterpillars become fluidlike and brick red. Upon death the body wall is easily punctured, allowing the fluids to spill over the tents and twigs. Large quantities of virus for subsequent use are obtained by collecting individual diseased or dead caterpillars, or by collecting the tents with the dead caterpillars. The collections are then mascerated in water in kitchen-type blenders, and transferred to glass jars. After 2 weeks the virus crystals have settled to the bottom and the extraneous top material can be poured off. The concentrate is calibrated, stored, and diluted at time of use. Or the virus can be held in the dried collections. Enough of the virus stock was collected in a few hours by one man to yield concentrate for several hundred gallons of spray. Each gallon contains about 2 billion polyhedra (microscopic bodies containing many virus crystals). Preliminary results indicate that 5 to 10 billion polyhedra in 2 to 5 gallons of water applied as a spray will control the caterpillar.

Equally encouraging was the natural spread of the virus into the tent caterpillar outbreak in Arroyo Hondo, Carson National Forest, New Mexico. Diseased caterpillars were first noted in 1955. Caterpillars died in great numbers in 1956. The infestation was nonexistent in 1957.

Applications of systemic insecticides to American elm

Application of dimefox (Fisons Pest Control Limited) to sapwood of American elms in 1956 indicates that the effectiveness of this systemic insecticide against the European elm scale carried over into the second season. A 50-percent concentrate of dimefox was introduced into half-inch holes drilled 4 inches deep around the base of each tree. The holes were then plugged. Dosages of 1, 2, and 4 milliliters per inch of girth were applied. Five elms were used for each treatment. Scale survivals per sample unit during the 1956 season had averaged 1.0, 8.2, and 0.2 for the 1-, 2-, and 4-milliliter dosages, respectively, as compared with 97 for the controls. A year later scale survivals were 0.5, and 0.3 per sample unit for the 1- and 2-milliliter treatments, respectively, as against 6.4 for the controls. The results do not imply a recommendation of dimefox for elm scale control by the method described.

The 4-milliliter dosage of dimefox was phytotoxic to the elms and far in excess of the requirements for scale control. At this high dosage, one or more branches per tree were killed. Other less serious injuries observed were stunting of 1956 twig growth and marginal burn of leaves. The trees subjected to the 2-milliliter treatment exhibited some twig stunting and some slight marginal leaf browning, but no branches were killed. Practically no toxic injury occurred in the 1-milliliter group.

On the basis of the high survival of scale insects following applications of dimefox as a soil drench in April 1956, it was tentatively concluded that the chemical was held from the roots by dry soil particles. The experiment, therefore, was repeated in 1957 on elms growing on soil with good moisture conditions. Phosdrin and Thimet were also tested. Again the scale populations differed little from those on the control. The negative results from the 1957 tests could have two explanations: (1) Elms will not absorb effective amounts of the chemicals when applied as a drench about the base of the trees; (2) the timing of the application was unseasonable. In the Fort Collins area, the peak of physiological activity in American elm comes late in May. Major leaf growth and twig elongation are about completed by the first week in June. The scales hatch and begin feeding in late June. As in 1956, applications might best be made in late April.

Results from studies with systemic insecticides on Engelmann spruce

Applications of dimefox, demeton, and Thimet were made on a series of Engelmann spruce on July 20, 1956. Formulations of Thimet (47.5 percent emulsifiable), Systox (2 pounds demeton per gallon), and Hanane (50 percent dimefox) were used. Undiluted quantities of these three systemic insecticides were poured into half-inch holes drilled 4 inches deep, at a downward slant around the base of mature spruce. The dosages were 1, 2, and 4 milliliters per inch of girth. The liquids were absorbed in about 30 minutes after which the holes were tightly plugged with short maple dowels.

Soil drenches with 1-percent liquids of the same chemicals were made in depressions scraped to mineral soil about the bases of a second series of mature spruce. The quantity of liquid applied varied at the rate of 4, 8, and 16 milliliters per inch of bole circumference, measured about a foot above the duff.

Of the three chemicals used, only dimefox produced phytotoxic symptoms at the close of the 1957 season. The tree implanted at the 1-milliliter rate was almost dead when examined July 26, 1957. The branches on about 5 feet of the upper crown contained fading needles. The 2- and 4-milliliter implant treatments appeared normal.

In the determination of extent of distribution of systemic insecticides in plants, it is an asset to treat specimens infested with sucking insects whose reactions provide an index to the rate and direction of translocation, or to use an insecticide containing a radioactive element.

In uninfested spruce, such handicaps might be overcome by inducing artificial infestations of bark beetles. Two such approaches are under study: (1) Girdling trees with caged adult Engelmann spruce beetle, and (2) implanting spruce beetle eggs or newly hatched larvae under the bark. Preliminary results suggest that both approaches will be satisfactory.

Ethylene dibromide for Douglas-fir beetle control

A chemical control test using ethylene dibromide emulsion on Douglas-fir infested with the Douglas-fir beetle was completed in early June near Pikes Peak. This was the second trial of ethylene dibromide against the Douglas-fir beetle. The first was made in 1956 on Derby Mesa on the White River National Forest in Colorado. In each test 10 trees on the area were left untreated. Two weeks or more after the completion of each treatment, 10 treated and the 10 untreated trees were felled; two 6"x 6" bark samples were taken at 5-foot intervals up to the maximum height of infestation on each tree. Counts of living beetles and dead beetles were recorded for each sample and analyzed. All beetle stages were included. The results appear below:

Year of treatment	Area	Mortality of Douglas-fir beetles	
		Treated trees (Pct.)	Untreated trees (Pct.)
1956	Derby Mesa	91.6	39.2
1957	Pikes Peak	91.6	7.3

Although the insecticide was definitely toxic to the Douglas-fir beetle, it cannot be concluded that this direct control program was successful. Other controlling factors have interfered. The current infestation decreased from last year's by 4 trees to 1 on the treated area, but there was a decrease of 2 to 1 on the untreated check area.

Woodpeckers kill Engelmann spruce beetles

Woodpeckers eat large quantities of spruce beetles. They also kill the beetles indirectly by removing bark. The effects of feeding were determined by counting the surviving beetles in two samples from each of 225 infested trees. One sample was from an area of the bole protected from woodpeckers by a hardware-cloth cage; the other, from an unprotected area. Figure I-4 shows a tree with much bark removed and heavy woodpecker feeding.

Figure I-4. --This is an example of the heavy classification of woodpecker feeding on a tree intensively infested with Engelmann spruce beetles.

Table I-3. --Effect of woodpecker feeding on survival of Engelmann spruce beetles

Woodpecker feeding class	Trees	Beetle survival per square foot of bark		
		Caged	Uncaged	Reduction
	No.	No.	No.	Pct.
Light	41	39 ± 9	22 ± 6	44
Light to moderate	24	73 ± 13	30 ± 11	59
Moderate	36	88 ± 11	32 ± 8	64
Moderate to heavy	28	99 ± 11	16 ± 5	84
Heavy	96	113 ± 8	2 ± 1	98

Parasitism of Engelmann spruce beetle larvae

Coeloides dendroctoni Cush. is the most common insect parasite of the Engelmann spruce beetle. Its effects on host populations were measured at 13 areas of infestation. The parasitism as computed for areas of the bole not protected from woodpeckers is shown in table I-4.

Table I-4.--Parasitism by Coeloides dendroctoni in various infestations of the Engelmann spruce beetle

Status of spruce beetle infestations	Trees sampled	Beetle population under bark		
		Total	Parasitized by Coeloides	
		No./sq.ft.	No./sq.ft.	Percent
Increasing	24	18.7	1.9	10
"	22	87.5	1.4	2
"	17	27.4	0.8	3
Static	24	13.2	0.3	2
"	24	22.9	2.1	9
Decreasing	27	1.5	0.3	20
"	23	1.7	0	0
"	20	3.7	1.0	27
"	23	12.1	6.4	53
"	21	6.0	1.1	19
"	16	5.0	0	0
"	24	2.2	0	0
"	21	2.1	0	0

In general, the number of Coeloides per square foot of bark remained constant regardless of the size of brood available for parasitism. In one case, however, parasitism was unusually high, 6.4 square feet. In this instance, Coeloides materially reduced the beetle population. Adults tend to congregate over small areas of bark and parasitize practically every larva in these pockets, leaving larger areas of the bole with no parasitized larvae. These parasites are not commonly found where bark is thick.

FOREST UTILIZATION RESEARCH

During the past year major emphasis in Forest Utilization Research was given to studies designed to expand the harvest of little-used species through improved harvesting and improved quality determination. Highlights of the work accomplished include the following:

Larger timber harvest needed in high-mountain sites in central Rockies

An analysis made during the past year showed that for the area as a whole, growth is about 2.75 times as much as drain. Increasing the cut in lodgepole pine, true firs, and aspen appears to offer the best means for adjustment.

Saw logs constitute approximately two-thirds of the present annual cut of primary forest products. Pulpwood production makes up less than 1 percent. Ninety-seven percent of the sawmills in the area are circular-type mills and average less than 5 million board-feet annually. Only 20 percent of the lumber produced in the area is used in local remanufacturing industries. Forest products industries constitute 7 percent of the total manufacturing establishments and 3 percent of the total employment. For Wyoming, the ratio is 30 and 16 percent, respectively; and in Colorado, 12 and 4 percent.

Trial log grades look good for lodgepole pine

The trial log-grading system developed for associated species in the Pacific Northwest was tested on Colorado lodgepole pine. Analysis of the results based on the quality- index concept (an expression of value per M b. m. in which the price of No. 3 common, S4S, H/4 lumber is the base) showed that the grading system separated the logs into significantly different value classes as shown in table U-1.

A similar test based on diameter classes showed that diameters were of little value in separating the logs by quality classes. Figure U-1 shows a comparison of the lumber recovery by log grade and diameter classes.

Table U-1.--Average quality index of lodgepole pine

Log grade	Logs	Average quality index		
		Sound logs	Defective logs	All logs
	No.			
1	71	116.0	108.4	114.6
2	84	109.2	102.2	107.5
3	206	106.5	94.6	103.5
4	466	101.7	90.0	99.1

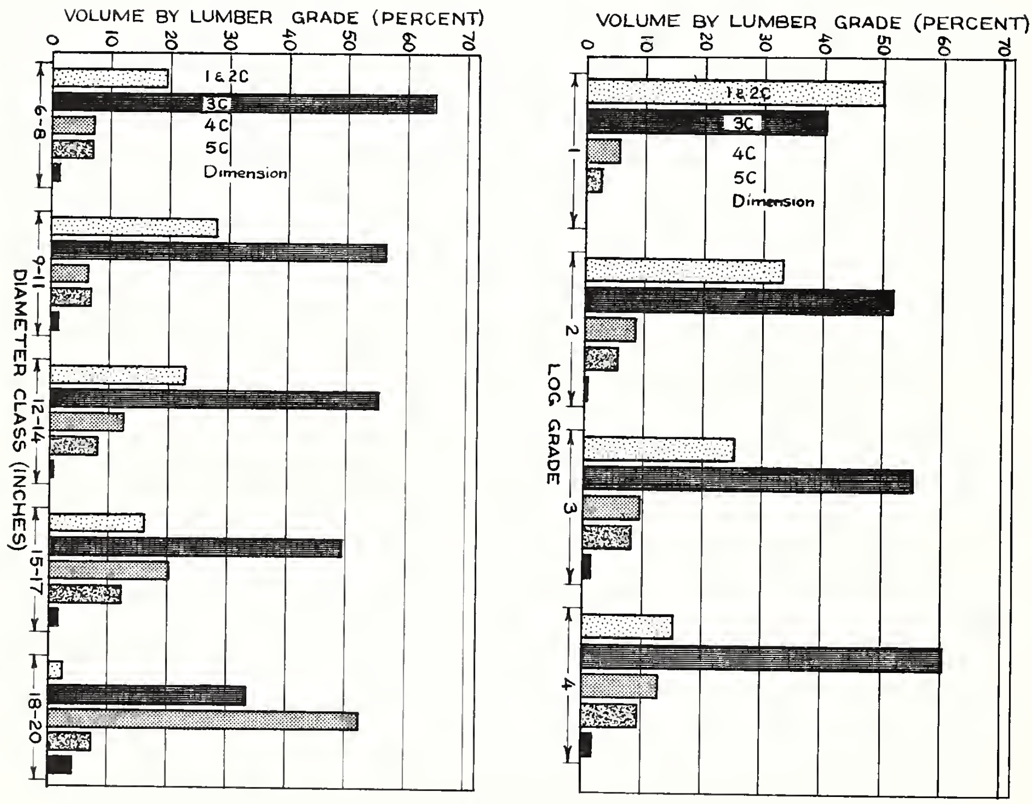


Figure U-1.--Comparison of the lumber recovery by log grade and diameter classes.

Round-log gang and circular headsaws compared

An exploratory test was made in sawing lodgepole pine to compare the relative merits of a round-log gang and a circular headsaw. Sawing time records were kept on both headsaws by logs of known grade and scale. The recovery of lumber was likewise recorded by grade and volume. From this information, the production rate, as well as some leads on the quality of production, was determined.

As would be expected the gang headsaw showed up best in production. This advantage was most pronounced in the smaller diameters (table U-2). The relatively good showing of the gang headsaw in the quality comparison was less expected (table U-3). The design of the gang headsaw provides little opportunity to upgrade by turning the logs as is commonly done on the circular headsaw. Because of this, gang headsaws are not recommended when sawing for grade.

Table U-2.--Sawing time as related to log diameter (Minutes per M b.m. lumber tally -- uncurved data)

Diameter inside bark (inches)	Gang headsaw		Circular headsaw	
	Mill time	Logs	Mill time	Logs
	Min.	No.	Min.	No.
6	--	--	127.57	1
7	27.83	15	61.80	12
8	25.08	78	51.43	60
9	20.08	88	40.60	81
10	15.77	80	32.15	81
11	12.50	69	28.57	48
12	11.03	48	23.54	52
13	9.29	15	18.69	37
14	8.66	6	20.05	22
15	5.90	1	14.57	17
16	12.73	1	15.87	14
17	--	--	15.39	6
18	--	--	9.90	1
19	--	--	--	--
20	--	--	13.09	3
Average	15.63		26.68	

Table U-3. --Average quality index of sound logs by mill type and log grade

Log grade	Average quality index		
	Gang headsaw	Circular headsaw	Both headsaws
1	116.3	114.6	116.0
2	109.3	108.3	109.2
3	108.6	105.2	106.5
4	103.4	100.6	101.7
Average	107.9	103.3	105.7

This rather unusual finding might be partially explained by the fact that the general quality of lodgepole pine logs is such that it is not possible to develop much grade by any method of sawing. Also, the better-quality logs within a given grade are generally sent to the gang mill. Pronounced crook or other irregularities would make it difficult to run the log through the gang headsaw.

Colorado lodgepole pine yields good lumber in common grades

Tests show that Colorado lodgepole produces a high percentage of lumber in good-quality common grades. A breakdown by lumber grades of the yields of 827 lodgepole pine logs studied recently showed the following distribution:

Grades	Percent
1 & 2 common	23.87
3 common	55.97
4 common	10.75
5 common	8.06
Dimension	1.35

Private logging firm to continue tests of skyline-crane

To further evaluate the skyline-crane logging system, in operation on the Fraser Experimental Forest, arrangements have been completed to have a private logging company operate the system during 1958. The logging company will furnish a complete record of costs, and make needed changes in equipment.

The cableway for cutting strip C (fig. U-2) will be nearly 2,800 feet (42 chains) long and the skyline will be suspended over slopes as steep as 90 percent, with an average slope of 42 percent. More than 250,000 board-feet of timber will be cut and logged from the 17 acres within the cutting-area boundaries.

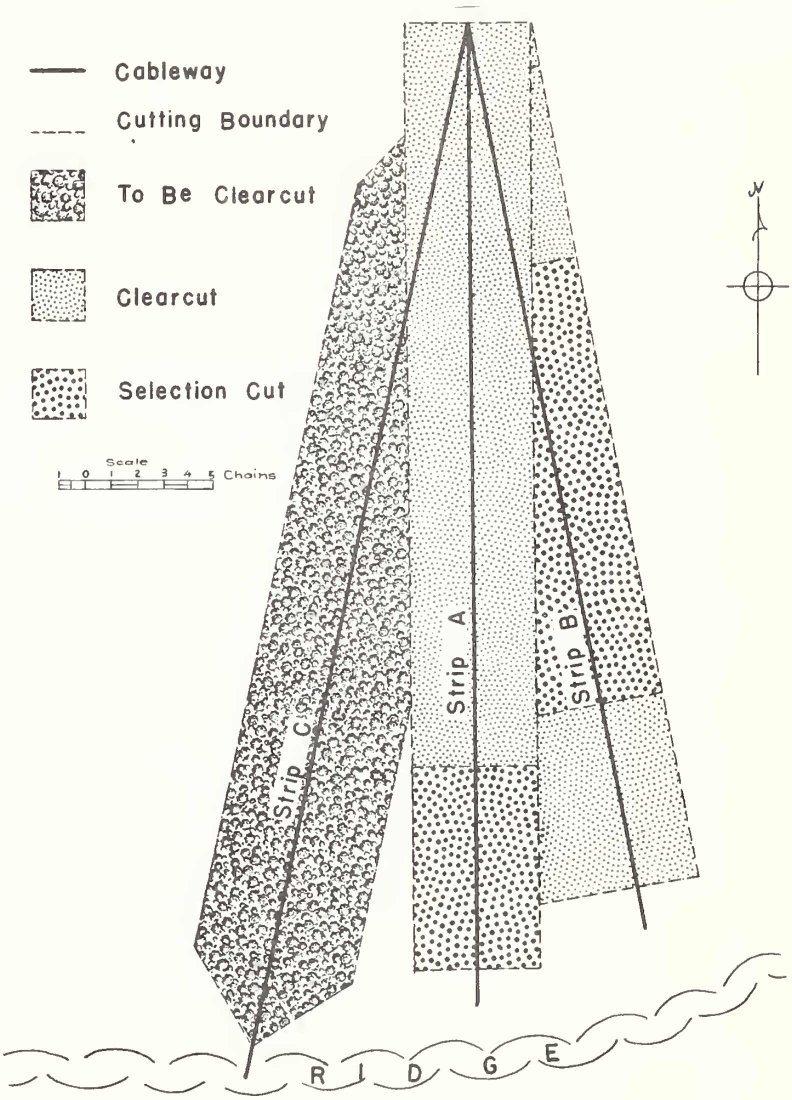


Figure U-2.--Skyline-crane settings on West St. Louis Creek, Fraser Experimental Forest, Colorado.

Combined cost data for 2 years of operation by students, using two different inexperienced crews, give high but not excessively unfavorable logging costs for harvesting timber from the steep slopes. Costs and performance data for 150,000 board-feet in logs averaging 16 logs per M b.m. are summarized in the following tabulation:

		Cost per 1,000 board-feet
Stumpage		$ 3.00
Falling and bucking		6.60
Installation (2 settings)		7.90
Yarding and skidding:		
Labor (includes supervision)	$12.18	
Gasoline and lubricants	.26	
Reserve supply and parts fund	3.00	
Depreciation	1.00	16.44
Total, f.o.b. landing		33.94
Hauling, 8 miles		5.50
Total, f.o.b. mill		$39.44

Excluded from the preceding tabulation is 50,000 board-feet of timber logged from the selection-cut areas. Logging was slow and costly in those areas where less than 15 percent of the merchantable volume was removed. Included in the tabulation are costs for training inexperienced logging personnel in installation and operation of the equipment.

On the Fraser Experimental Forest, the skyline-crane opened up for logging some 600 acres of steep timberland. This required no road building and only a one-third-acre clearing for a landing. Road costs were practically eliminated. Watershed benefits often result from the use of overhead cable logging systems in small timber, on steep slopes. Many timbered areas considered physically or economically inoperable may be tapped by this new cable system.

Chemical peeling of ponderosa pine looks promising in the Black Hills

Bark was easily peeled in November from ponderosa pines poisoned between May 20 and June 18. Peeling became more difficult as the poisoning date progressed from this optimum period. Upper bolts cut from trees treated before and after this optimum period were most difficult to peel. However, chemical peeling during this period was still easier than peeling untreated trees during the optimum spring growing season. Figure U-3 shows a comparison of the two peeling methods by time of treatment.

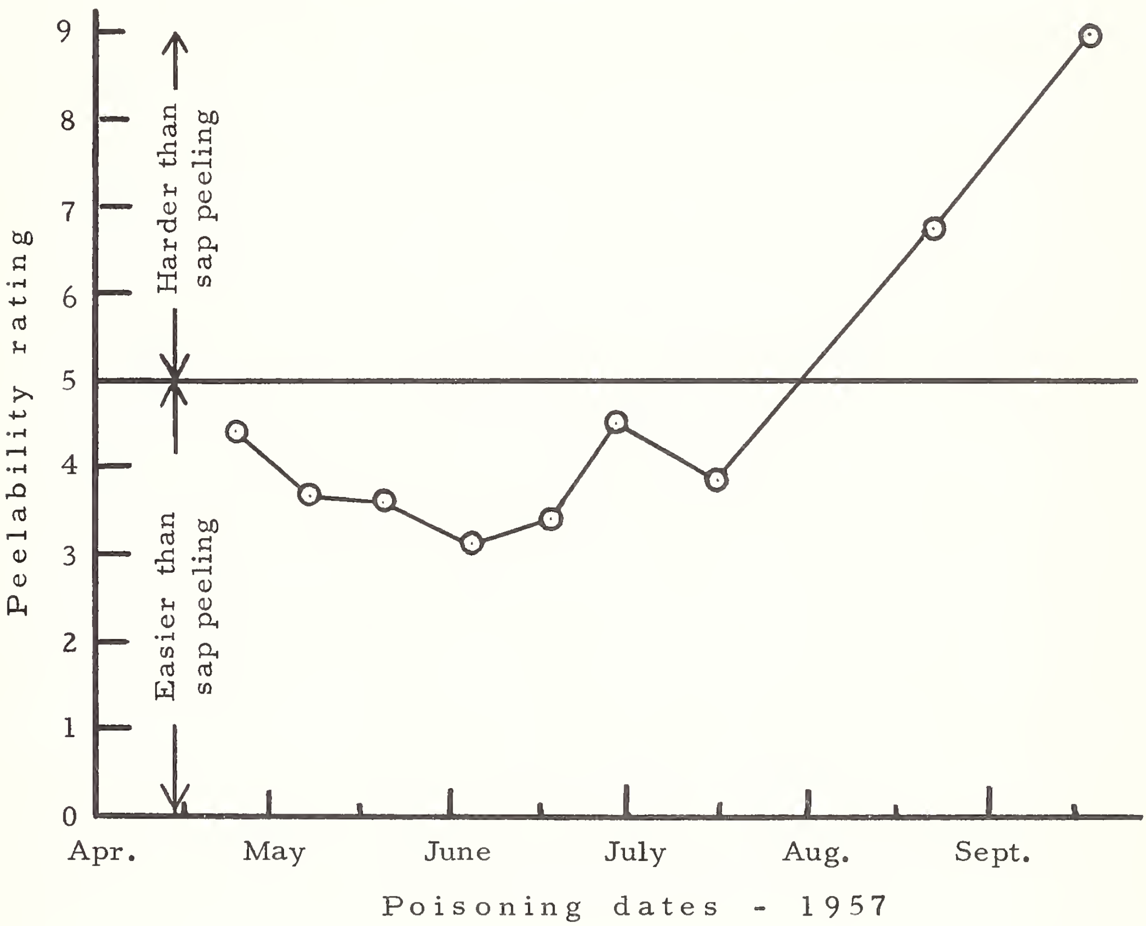


Figure U-3.--Relationship between peelability and poisoning dates. Each point represents the average peelability for six trees containing from two to five bolts.

The poison (40 percent sodium arsenite) was applied to stump height girdles at 9 different periods between April 24 and September 18. Width of each girdle was equal to the diameter of the tree. Trees scheduled for testing in November were felled and bucked into 100-inch pulpwood lengths. Evaluations of peelability were made on the basis of how easily the bark loosened.

In addition to loosening the bark, the treatment also reduced the green weight of the wood by 16 to 33 percent. Poisoned trees did not appear to attract insects or wood-staining fungi. Followup studies will evaluate the effect of freezing and thawing.

Nitric acid pulping process evaluated

Recent improvements in the nitric acid pulping process make possible the recovery of up to 95 percent of the acid. This has brought about increased local interest in this pulping method, which has long been recognized for its adaptability to a wide range of mill sizes, capital, water, and market requirements. Other characteristics of the process are its high pulp yields (up to 55 percent of ovendry weight of the wood), short reaction time (1 to 3-1/2 hours), and lack of offensive odor.

A sample of beetle-killed Engelmann spruce was tested by this process at the pilot plant in Vancouver, British Columbia. Results showed that spruce pulped readily and in general the processing conformed closely to all claims made by the inventor, Dr. J. X. Desforges. The pulp was evaluated by the Forest Products Laboratory. Their tests showed that nitric acid pulp beat into the desired consistencies much quicker than sulfate pulp. The pulp also developed relatively good bursting and tensile strengths. In tear resistance, it rated somewhat low for a good grade of kraft wrapping paper. The alpha-cellulose content was found to be 81 percent, which is about average for chemical pulps that are to be further refined for dissolving pulp.

Colorado lodgepole pine produces good-quality plywood

Results of a test made to evaluate lodgepole pine for veneer and plywood production showed that this species had good properties. As would be expected, the yields of clear veneer were low and generally ruled out the feasibility of producing plywood products requiring clear face stock. A relatively high percentage of the volume, however, proved suitable for a good-quality sheathing grade.

Spruce produced high-quality charcoal

Analysis of charcoal produced from beetle-killed Engelmann spruce in steam-heated retort showed that the wood produced a high-carbon, low-volatile charcoal comparable to low-density hardwood such as willow and aspen. The Forest Products Laboratory rated it a very good-quality, low-density charcoal. Results of the analysis, along with those of other species that were tested during the year are shown in table U-4. Oak-hickory is included as a standard for comparison.

Table U-4. --Chemical analysis of charcoal from different woods

Species	Moisture content	Total volatile	Carbon	Ash	Specific gravity
	Percent, ovendry weight of wood				
Alligator juniper	5.54	27.62	72.41	0.56	0.30
Utah juniper	4.21	20.62	78.52	.86	.36
Engelmann spruce	1.46	12.16	86.88	1.16	--
Mesquite	1.41	10.18	82.42	7.40	.41
Oak-hickory	2-3	16-22	75-82	1-5	.37-.50

Charcoal production slightly less than 500 tons in 1956

A survey made of the 1956 charcoal production in the station area showed that production was almost 500 tons. The national production for the same period amounted to 264,990 tons. Local production was found to be confined to Arizona. It consisted entirely of lump charcoal made from mesquite wood. Results of the national survey are available in the report, "Charcoal production in the United States," Division of Forest Economics Research, U. S. Forest Service, Washington, D. C.

Strength properties of Douglas-fir found to vary widely

The desirability of placing Douglas-fir under a single set of basic stresses has long been recognized. In view of the marked inroads made over the years in the supply of high-quality coast-type fir, long considered in a class by itself, many authorities in the wood-engineering field felt that the difference in quality over the range has lessened. With this in mind, a series of studies were undertaken to reevaluate the strength classification. Sample material was selected in Arizona, New Mexico, Colorado, Montana, Idaho, and in all the Pacific Coast States. The material was sent to the Forest Products Laboratory, where the tests were conducted and the results were analyzed. Overall results show that the strength properties of the species differ widely and too greatly to be considered as a single population. There is strong evidence that at least 2, or possibly 3, populations are involved. Analyses of the data show a reasonably consistent distinction between the typical Douglas-fir (*Pseudotsuga menziesii*) and the varietal form Douglas-fir (*P. menziesii* var. *glauca*). Within the latter group, a secondary separation of the northern and southern Rocky Mountain area appears to exist.

RANGE MANAGEMENT RESEARCH

Abundant moisture in 1957 throughout the Rocky Mountain area broke the drought. Many ranges improved considerably and often showed remarkable response where reasonably good vigor and stand of forage plants remained.

A cold, wet spring delayed plant development on the high mountain ranges, and the grazing season was necessarily shortened. Other areas, particularly the lower elevations in the Southwest, received spotty rainfall and the production of forage varied accordingly. For example, on one part of the Santa Rita Experimental Range near Tucson, Arizona, precipitation was 53 percent below the longtime average; but over most of the area, precipitation was adequate and well distributed.

During 1957, grazing treatments were applied for the first time to Thurber fescue ranges on Black Mesa in western Colorado. The treatments are to determine the effects of different levels of grazing on ecological trends, forage production, beef production, and watershed conditions of this important mountain grassland type.

Studies also were started to evaluate the effects of grazing at different seasons on semidesert grass-shrub ranges in Arizona and seeded ranges in the ponderosa pine zone of Colorado. Basic research was begun on seasonal trends of heat and desiccation resistance and moisture content of the important grasses and trees of the pinyon-juniper type in Arizona. This will be followed by investigations of ways to control juniper by burning. Comparisons of nutritive value of forage species were begun in the Black Hills, in cooperation with the South Dakota Agricultural Experiment Station; and a study to test the use of range seeded to crested wheatgrass for lambing was initiated in cooperation with the New Mexico Agricultural Experiment Station.

Grass response varies with grazing and soils

In the Big Horn Mountains of Wyoming the total density of the six main grasses on soils derived from granite (mainly Burgess gravelly loam) decreased more than 50 percent from

1951 to 1956 under heavy and moderate use but only 8 percent under light use (fig. R-1). On soils from sedimentary rocks (primarily Owen Creek silt loam derived from shale), density decreased 73 percent under heavy use but only 21 percent under moderate and light use. The six grasses are Idaho fescue (Festuca idahoensis), spike fescue (Hesperochloa kingii), bearded wheatgrass (Agropyron subsecundum), slender wheatgrass (A. trachycaulum), pumpelly brome (Bromus pumpellianus), and big bluegrass (Poa ampla).

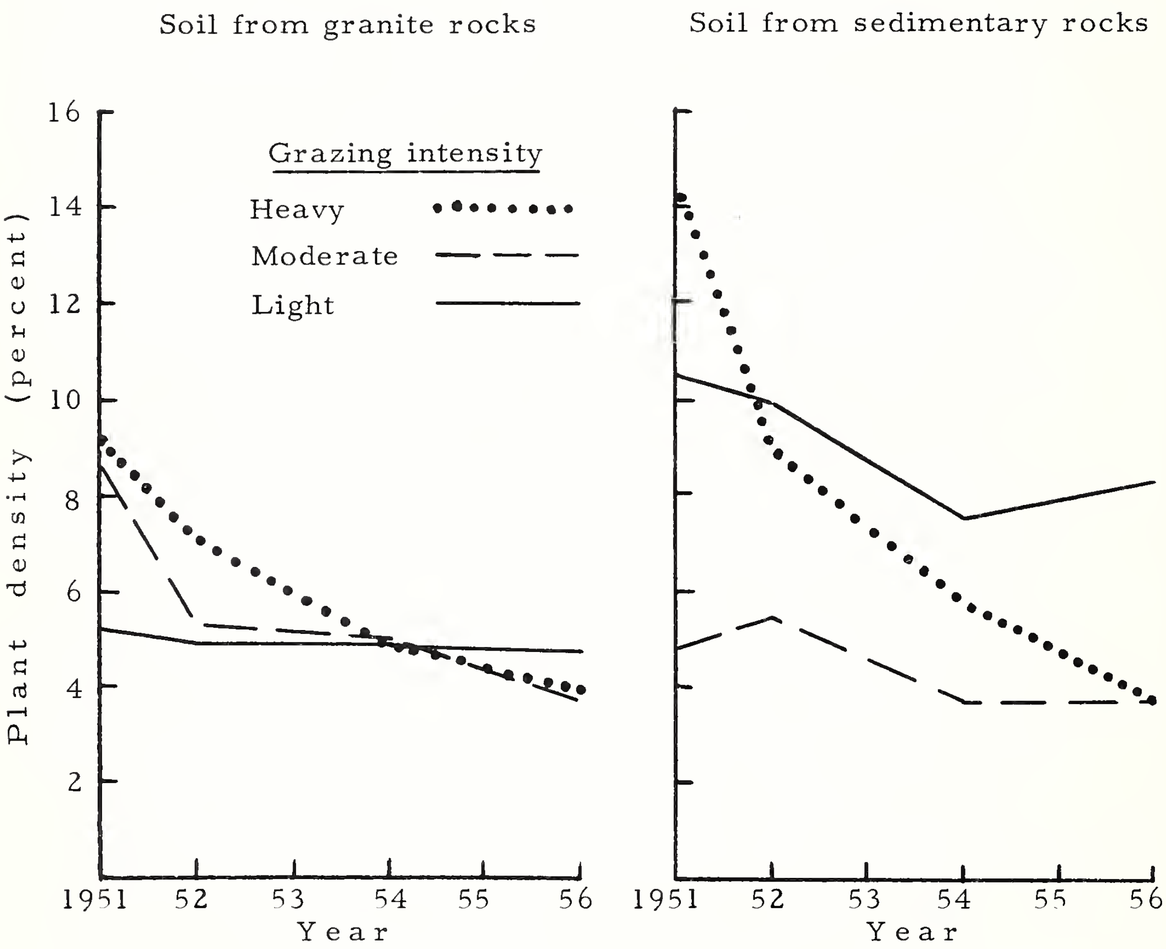


Figure R-1. --Changes in density of six grasses (Idaho fescue, bearded wheatgrass, slender wheatgrass, pumpelly brome, spike fescue, and big bluegrass) as related to soils and different grazing intensities.

Herbage production of the six grasses has also been influenced by the different grazing intensities (fig. R-2). Relative to 1951, herbage production on both soils has decreased under heavy and moderate use and increased under light use.

In these studies both density and herbage production have varied widely from year to year because of weather differences, and on the average decreased for the first 3 years because of relatively low precipitation received. But effects of grazing intensities and soils are beginning to become apparent.

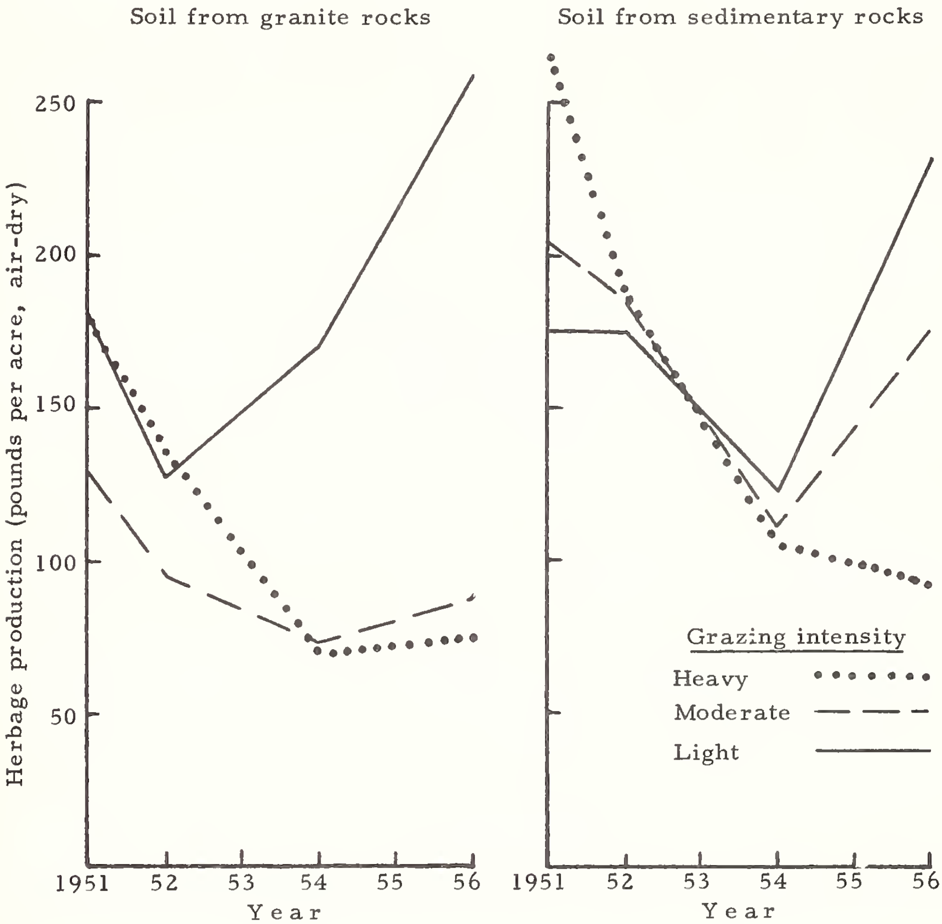


Figure R-2. --Changes in herbage production of six grasses (Idaho fescue, bearded wheatgrass, slender wheatgrass, pumpelly brome, spike fescue, and big bluegrass) as related to soils and different grazing intensities.

From results thus far it appears that (1) the heavy rate of grazing is detrimental to the vegetation on both soils; (2) the moderate rate of grazing may not injure the vegetation on the soils derived from the sedimentary rocks but may reduce both density and production on the soils derived from granite; and (3) the light rate of grazing is not adverse on either soil.

Forage preference of sheep on mountain grasslands

On sheep ranges studied on the Bighorn National Forest the plants that are most abundant and are usually considered the most desirable were found to be relatively low in preference to sheep. Grasses and sedges constituted 52 percent of the plant cover; and forbs, 48 percent. Idaho fescue, timber danthonia (*Danthonia intermedia*), and Sandberg bluegrass (*Poa secunda*) were the most abundant grasses. Fleabanes (*Erigeron* spp.) were the most abundant forbs, but avens (*Geum* spp.), ballhead sandwort (*Arenaria congesta*), and flowery phlox (*Phlox multiflora*) were also common. The ten plants taken by sheep, in descending order of preference, were silky crazyweed (*Oxytropis sericea*), aster *Aster* spp.), silky lupine (*Lupinus sericeus*), wheatgrass (*Agropyron* spp.), needleleaf sedge (*Carex eleocharis*), Ross sedge (*C. rossii*), brome grass (*Bromus* spp.), Sandberg bluegrass, fleabane, and prairie Junegrass (*Koeleria cristata*).

Gopher populations reduced by spraying rangeland with 2,4-D

Pocket gopher populations were greatly reduced on a grass-forb range as the result of airplane spraying with 2,4-D. The studies were conducted on Grand Mesa in western Colorado in cooperation with the Colorado Agricultural Experiment Station and the U. S. Fish and Wildlife Service.

In 1956, 2,000 acres were sprayed with a butyl-ester formulation of 2,4-D. Prior to spraying, herbage production and gopher populations were sampled on plots located within the area to be sprayed and in untreated check areas. Similar data were taken on all plots in 1957.

Changes in herbage production and total pocket gopher numbers in 1956 prior to spraying and in 1957 following spraying, on the sprayed and the check plots were as follows:

	Grass production	Forb production	Pocket gophers
	(pounds per acre)		(No.)
Sprayed plots:			
1956	198	399	117
1957	272	120	15
Unsprayed plots:			
1956	137	650	101
1957	138	539	110

The number of gophers dropped 87 percent on the sprayed plots but increased 9 percent on the check areas. The vegetation meanwhile changed from a forb aspect to one dominated by grasses on the sprayed plots, but forbs remained prominent on the unsprayed plots.

Pine-bunchgrass ranges

Production of grass and sedge herbage has held up for 16 years on pine-bunchgrass ranges at Manitou Experimental Forest where grazed at moderate and light intensities each year. On heavily grazed range, production fell off by more than half. Estimates of average production on experimental ranges for 1942 at the beginning of the study and in 1957 are as follows:

Grazing intensity	Grass and sedge herbage 1942	Grass and sedge herbage 1957
	(pounds per acre)	
Light (10 to 20 percent removal)	317	335
Moderate (30 to 40 percent removal)	361	446
Heavy (50+ percent removal)	351	148

Grazing too heavily retards development of forage plants

The 16 years of heavy and moderate grazing at Manitou Experimental Forest has markedly reduced growth of both leaves and flower stalks of the valuable Arizona fescue (*Festuca arizonica*) as compared with light grazing (fig. R-3). Reduction from heavy grazing greatly exceeded that from moderate grazing. The effects of the different intensities of grazing were also apparent on mountain muhly (*Muhlenbergia montana*) but were not so great as on Arizona fescue.

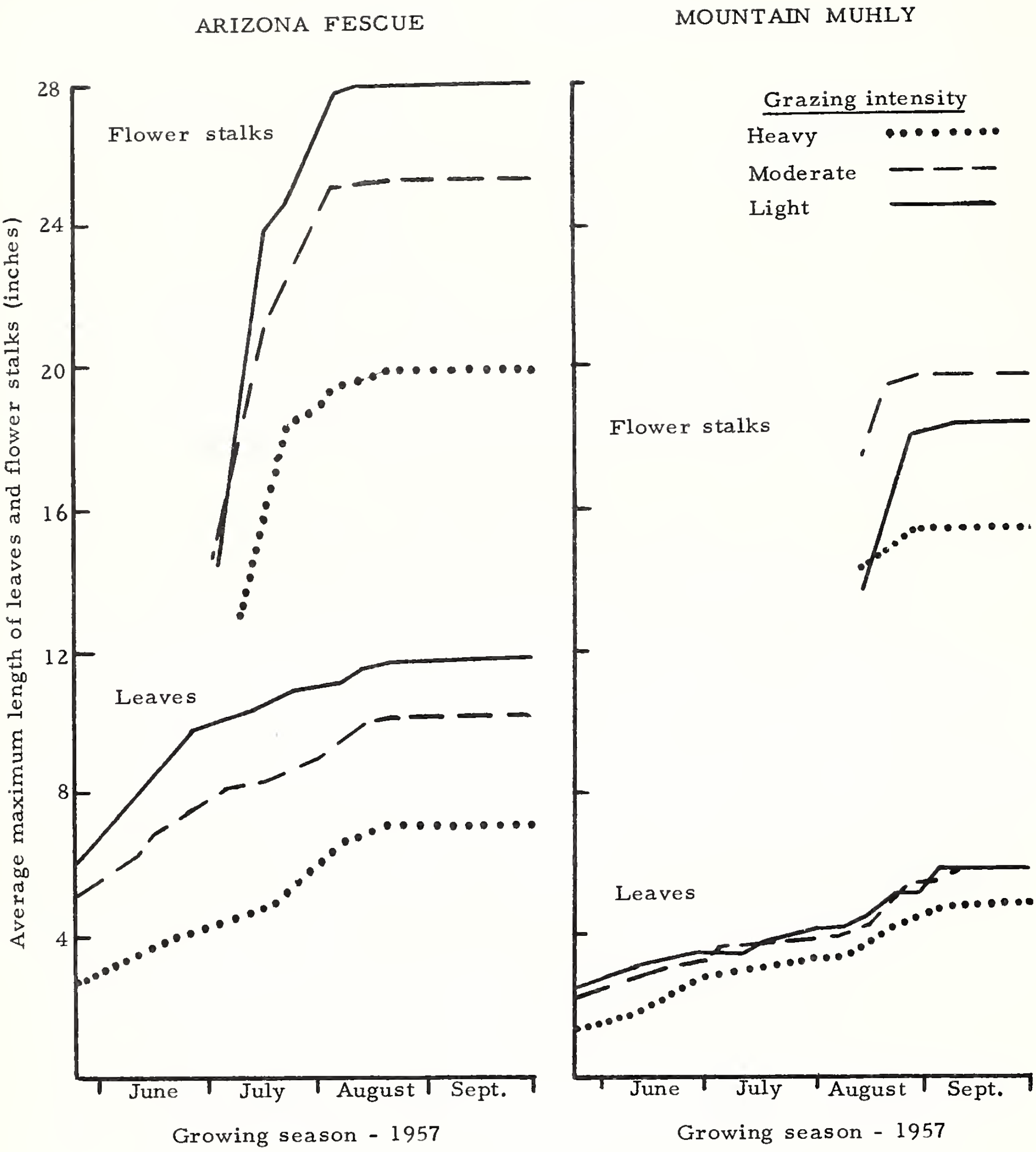


Figure R-3.--Leaf length and flower stalk development of Arizona fescue and mountain muhly as affected by 16 years of grazing at three intensities, Manitou Experimental Forest, Colorado.

Grazing also delayed spring leaf growth. Average maximum lengths of Arizona fescue leaves measured May 29, 1957, were twice as great for moderate and light use as for heavy use (6.2 inches as compared with 3.1 inches). Leaf lengths from comparable measurements on mountain muhly were: Heavy, 1.3 inches; moderate, 2.2 inches; light, 2.0 inches.

The number of flower stalks per plant and percentage of plants with flower stalks were also related to grazing intensity as shown by measurements in 1950 (table R-1).

Table R-1. --Comparison of flower stalk development of two range grasses, Manitou Experimental Forest, 1950 and 1957

Species and intensity of grazing	Plants with flower stalks		Flower stalks per flower stalk-bearing plant	
	1950	1957	1950	1957
	Pct.	Pct.	No.	No.
Arizona fescue				
Heavily grazed	5	10	1.0	1.7
Moderately grazed	15	60	2.5	8.4
Lightly grazed	20	55	4.5	10.5
Mountain muhly				
Heavily grazed	45	50	6.0	3.0
Moderately grazed	70	75	11.0	6.4
Lightly grazed	95	55	12.5	13.2

In 1950, an inverse relationship between grazing intensity and percentage of plants flowering and number of flower stalks on those that did flower was evident (table R-1). By 1957, this inverse relationship was even more pronounced, except for percentage of mountain muhly plants with flower stalks.

Spring, fall, and spring-fall grazing on crested wheatgrass range being tested

In comparisons of spring, fall, and spring-fall grazing of crested wheatgrass at Manitou Experimental Forest, the fewest heifer-days' grazing were obtained from spring grazing and the most from spring-fall grazing as shown by the following tabulation.

Grazing period	Yield of crested wheatgrass (pounds per acre)	Heifer days per acre (No.)
Spring only	1,734	48
Fall only	1,894	75
Spring-fall	2,457	104
(Spring)		(55)
(Fall)		(49)

In the spring, cattle grazed all plants to a relatively uniform stubble. However, in the fall after crested wheatgrass had cured, grazing was not uniform. A pattern of tiny islands of closely cropped plants began to appear by October 1 in the areas grazed only in the fall. These islands expanded but never fully joined as the season progressed. When the cattle were finally removed, about three-fourths of the stand had been grazed as closely as physically possible, and the remaining one-fourth had received no apparent use. Similar islands were not present in areas grazed both in the spring and the fall. Apparently, the spring grazing prevented formation of coarse material, and animals were less selective when they were returned in the fall.

Severe drought in 1956 killed crested wheatgrass

The exceedingly dry year of 1956 killed many crested wheatgrass plants in northern New Mexico. Precipitation in 1956 at Tres Piedras, New Mexico, was 6.12 inches, 41 percent of the longtime average. In August 1957, the number of dead crested wheatgrass plants on nearby experimental pastures was:

Kind of spring grazing received	Dead crested wheatgrass plants (No. per sq. ft.)	(No. per acre)
Heavy	0.2662	11,596
Medium	.1644	7,161
Light	.0903	3,933
Ungrazed (3 exclosures)	.0727	3,167

Spring grazing at the heavy and medium intensities contributed materially to death losses of crested wheatgrass during the dry year. The difference between the average number of dead plants in the exclosures and in the lightly grazed pasture was not statistically significant.

Cattle weight gains reflect grazing intensity during drought

Weight gains of cows grazing crested wheatgrass in the spring in northern New Mexico varied inversely with the degree of utilization from 1953 to 1955, inclusive. However, no important differences between weight gains of calves were observed (table R-2). With the reduced plant vigor and herbage production that resulted from the extremely dry 1956, differences developed in daily weight gains of the calves as well as the cows. In 1956 and 1957 weight gains of the calves were greatest on lightly grazed range, lowest on heavily grazed range, and intermediate on range grazed at medium intensities.

Table R-2. --Average daily gains of cows and calves during month-long spring grazing in north-central New Mexico (Cebolla Mesa)

Grazing intensity	Average daily gains			
	Cows		Calves	
	1953-55	1956-57	1953-55	1956-57
	- - - - Pounds per day - - - -			
Light	4.5	4.3	2.4	2.2
Medium	4.1	2.1	2.4	1.8
Heavy	3.2	1.9	2.5	1.7

Relation of tree canopy to understory plants in pinyon-juniper type

Changes in composition of the herbaceous and shrub vegetation were small between 1939-43 and 1953 in pinyon-juniper forests with dense canopies in north-central New Mexico. By contrast, in open stands perennial grasses increased materially in percent composition, and shrubs decreased. In open stands short-lived species such as snakeweed (*Gutierrezia* spp.) made up about 60 percent of the plant cover at the time of the first measurement. By 1953, they comprised less than 20 percent, while perennial grasses increased from 35 to 65 percent of the cover. Composition changes in stands of medium tree density were intermediate between changes in the dense and open stands.

Density of perennial grasses in 1953 was 4 to 5 times as abundant in the open stands as in the densest stands studied. In the open stands density was higher inside fenced exclosures than on adjoining grazed range. Also, there was less shrub density where protected than where grazed. Under the dense stands grazing made very little difference. The average perennial grass densities for the conditions studied were as follows:

Average density of tree canopy (Pct.)	Sites (No.)	Average line transect density: Protected 10-14 years (Pct.)	Average line transect density: Open to grazing (Pct.)
38	3	3.0	2.9
22	3	9.5	6.3
2	6	15.2	11.9

Herbage production was measured at 10 sites in 1953. Yields from protected and grazed sites in relation to tree density were as follows:

Average density of tree canopy (Pct.)	Sites (No.)	Average air-dry herbage yields: Protected (Lbs./acre)	Average air-dry herbage yields: Open to grazing (Lbs./acre)
38	3	214	163
22	3	553	244
3	4	364	197

Chopping alligator juniper produces many new stems

Six treatments applied in 1945 to test methods of controlling alligator juniper (*Juniperus deppeana*) near Young, Arizona, were considered unsatisfactory as shown by 1957 results tabulated below:

Treatment	Live trees (No.)	Live stems (No.)	Stems per tree (No.)
Small trees grubbed out, larger trees pruned for post production; brush scattered	102	245	2.4
Small trees grubbed out, larger trees pruned; brush piled around bases of large trees and burned	115	210	2.2
Base of each tree burned with Houck torch	205	432	2.2
All trees cut to ground level	422	1,280	3.8
Small trees chopped, large trees girdled; all trees poisoned with sodium arsenite	152	288	1.7
Lower branches trimmed; trees burned with fuel-oil torch or by burning oil in trench around tree	145	272	1.9
No treatment	232	545	2.4

The juniper sprouted prolifically following all treatments. Cutting all trees to ground level resulted in the most stems (fig. R-4). Grubbing was effective in removing small trees, and burning and poisoning with sodium arsenite killed some trees.

In 1957 grass was sparse on all plots, and there were no apparent differences in grass density among the various treatments. Too many trees were present on all plots to allow development of more than a scattered grass stand.

Figure R-4.--A. Alligator juniper cut to ground level in 1945. B. Same area as it appeared in 1957.

Basal sprays kill many chaparral species

In tests at Sierra Ancha Experimental Forest in Arizona, several species of chaparral were readily killed by a single basal spray of a 50-50 mixture of 2,4-D and 2,4,5-T in a 5.8-percent solution. When applied to the lower 6 inches of each stem, it reduced numbers of live stems by the following percentages:

Species	Percent
True mountain-mahogany (*Cercocarpus montanus*)	100
Silktassel (*Garrya wrightii*)	100
Desert ceanothus (*Ceanothus greggii*)	99
Hollyleaf buckthorn (*Rhamnus crocea*)	72
Shrub live oak (*Quercus turbinella*)	25

A second basal application of the same strength applied 2 years later increased the kill to 100 percent of hollyleaf buckthorn and 88 percent of shrub live oak.

Chaparral shrubs recover following burning and seeding

Sprouting shrubs recovered quickly on the 1951 Pinal burn near Globe, Arizona. Sprouting was most rapid during the first 2 years. Crown density of the shrubs, composed principally of shrub live oak and sugar sumac (*Rhus ovata*), was 22 percent in 1952, 14 months after the burn, and 37 percent in 1956.

Sprouting of desert ceanothus was limited, and pointleaf manzanita (*Arctostaphylos pungens*) reproduced only from seed. Seedlings of both of these species were found early but made up only a small portion of the shrub vegetation by 1956.

Weeping lovegrass (*Eragrostis curvula*) seeded in the ashes soon after the fire, developed a good stand during the first growing season and continued to increase in density for the 5 years of study. Basal density of all perennial grasses was 1.28 percent in 1956. About 98 percent of this was weeping lovegrass.

Five years after the burn, sprouting shrubs had regained density that approximated shrub densities on unburned chaparral type. Shrubs most valuable as forage for livestock or game, such as desert ceanothus and hollyleaf buckthorn, constituted only a very small portion of the shrub cover. Weeping lovegrass gave quick cover, became well established, and seems to have a place for reseeding burns in the chaparral type of the Southwest.

Partial control of mesquite may justify the cost of aerial spraying on selected ranges in southern Arizona

Aerial application of 2, 4, 5-T is most promising for control of dense stands of velvet mesquite (Prosopis juliflora var. velutina). However, the best kill obtained to date ranges from 50 to 55 percent. To determine whether forage increases resulting from such partial control justify the costs, a study is being made on the Santa Rita Experimental Range in cooperation with the Agricultural Research Service.

In May 1954, 100 acres of mesquite were aerial sprayed with 3/4 pound of 2, 4, 5-T in 5 gallons of diesel oil per acre. Because of sparse understory vegetation, this area and some adjacent unsprayed range were seeded by airplane the same day to Lehmann lovegrass (Eragrostis lehmanniana) at the rate of 1 pound per acre. In June 1955, 50 acres were again sprayed with 2, 4, 5-T at the rate of 3/4 pound per acre; and 50 acres, at the rate of 1/2 pound per acre. Diesel oil carrier was again used at the rate of 5 gallons per acre.

The 1954 spraying completely defoliated most of the mesquite, but more than 90 percent of the trees sprouted or releafed within 12 months after spraying. The second application killed most of the tops. Plant kill increased to about 50 percent on the area re-treated with 3/4 pound of 2, 4, 5-T and to about 25 percent on the area re-treated with 1/2 pound of 2, 4, 5-T.

Native grasses, principally Arizona cottontop (Trichachne californica) and side-oats grama (Bouteloua curtipendula), made the most striking response to mesquite control, as shown in the following tabulation:

	Annual production			
	1954	1955	1956	1957
	- - - (Pounds per acre) - - -			
Native perennial grasses:				
Mesquite sprayed	343	600	314	710
Mesquite not sprayed	130	113	143	165
Seeded grasses:				
Mesquite sprayed	0	68	209	184
Mesquite not sprayed	0	0	15	46

Lehmann lovegrass also became established but not to the same extent as the native grasses.

The cost for spraying and seeding was $10 per acre, of which $7 was for mesquite control and $3 for seeding. Estimated values of the increased herbage production in terms of grazing capacity are $6.60 for native perennial grasses and $2.40 for Lehmann lovegrass, or a total of $9 during the first 4 years.

Benefits from the partial mesquite control will last for several more years and will return a profit through increased beef production. Thus, the rancher does not have to wait for better methods to start on his mesquite-control job. Present methods can be used profitably in selected areas.

Methods and benefits of mesquite control summarized in publication

U. S. Department of Agriculture Leaflet No. 421 entitled "Mesquite Control on Southwestern Rangeland" by H. G. Reynolds and F. H. Tschirley presents a summary of mesquite-control techniques. Grubbing, basal applications of oil, cabling or chaining, and foliage spraying are recommended as practical methods of controlling mesquite.

In the selection of a method, it is necessary to consider (1) the degree and location of the invasion, (2) age classes of trees in the stand, (3) optimum season for treatment, (4) availability of labor and equipment, (5) availability of funds, and (6) desirability of investment.

On a longtime basis, killing mesquite in its early stage of invasion is the best investment. Control becomes more costly as mesquite stands become more dense.

An increase in forage is the greatest benefit from mesquite control. A threefold increase in grazing capacity can frequently be expected. Other less tangible benefits also accrue from mesquite control: Livestock management is easier; screwworm infection is lower; and surface runoff and erosion are reduced.

Life history of some semidesert grasses

Studies of the reproduction and life span of several important range grasses of southern Arizona show that some grasses are benefited and others are retarded by grazing.

All grasses studied produced some seedlings or sets from stolons each year. The number, however, differed by species, year, and the presence or absence of grazing. For example, on ungrazed range the number of sets of black grama (*Bouteloua eriopoda*) varied from 0.4 new plant per meter-square quadrat in the poorest year to 8.0 in the best year; slender grama (*B. filiformis*) varied from 1.0 to 32.7 seedlings per quadrat. In general, grasses that tend to be more abundant on ranges in poor condition produced more seedlings than grasses more common to ranges in good condition.

Black grama (*B. eriopoda*), side-oats grama, hairy grama (*B. hirsuta*), and tanglehead (*Heteropogon contortus*) produced more new plants where protected than where grazed. In contrast, Texas timothy (*Lycurus phleoides*), Rothrock grama (*B. rothrockii*), sprucetop grama (*B. chondrosioides*), slender grama, and curly-mesquite (*Hilaria belangeri*) produced more new plants where grazed than where protected. Production of new plants by Arizona cottontop and mesa three-awn (*Aristida hamulosa*) apparently was unaffected by grazing.

Black grama, Arizona cottontop, mesa three-awn, and sprucetop grama were the longest lived, ranging from 10 to 14 years. No plant of Rothrock grama survived longer than 3 years where protected or longer than 4 years where grazed.

FOREST BIOLOGY

(In cooperation with U. S. Fish and Wildlife Service)

Pocket gopher control on Colorado rangeland

In a preliminary study to determine trends in pocket gopher numbers under different grazing treatments, most gopher activity was recorded on pastures grazed lightly and moderately by cattle. Least activity was recorded on the heavily grazed pastures. These grazing treatments were begun on the Black Mesa experimental pastures of the Gunnison National Forest in western Colorado in the summer of 1957. Mounds were counted in September to measure trends in pocket gopher populations.

The Denver Wildlife Research Laboratory of the U. S. Fish and Wildlife Service tested soil fumigants for use as gopher repellents. They also studied bait preservation, surface baiting, food habits, and coyote-gopher relations. Best bait preservatives kept the grain moldfree only 18 days, and acceptance by pocket gophers was poor. Surface baiting produced worthwhile results in early August. However, the control obtained by baiting in other summer months was low. In the work on food habits of gophers, a reference collection and slides showing root, stem, and leaf tissue of different plant species is being developed to aid in analysis of stomach contents. The collection now contains approximately 100 slides, with about 50 species of plants represented.

Pocket gopher and coyote trends were studied on two areas. On one of the areas coyote control had been practiced; on the other area no coyote control was done. There was no significant difference between results on the two areas.

Trend in rodent numbers on experimental areas

The small mammal trend on the six Black Mesa experimental pastures, where vegetative studies are being conducted under varying intensities of grazing, showed fewer animals present in 1957 than in 1956 or 1954. The small mammal catch per 100 trap nights in 1957 was 1.48 animals. In 1956 and 1954 the catch per 100 trap nights was 14.25 and 15.18, respectively. The small mammal population was apparently at a low in the cycle, and the drain on pasture vegetation from the above-ground rodents in 1957 was light.

On the Manitou Experimental Forest, slightly more animals were taken in the lightly grazed pastures than in either the moderately or heavily grazed treatments.

On the Badger Wash cooperative study area in the desert-shrub type of western Colorado, rodent trap lines showed similar rodent numbers in four ungrazed and four grazed watersheds. The rodent catch per 100 trap nights on the protected areas was 10.97; and on the unprotected areas, 9.86.

Forage production and wildlife use at Fraser

In the first rodent inventory on the cut and uncut strips on the Fool Creek watershed of the Fraser Experimental Forest, more animals were found on the cut strips than on the uncut areas. The greater rodent population on the cutover is due, presumably, to the superior cover and food conditions found in the form of logging slash and young conifer reproduction. About twice as many small mammals (32.78) were taken per 100 trap nights on the cut areas as were taken in the uncut forest (16.80).

FOREST ECONOMICS RESEARCH

Forest Economics Research activities are in two categories; namely, marketing studies and Forest Survey.

Marketing studies

Two marketing studies have just begun. Both are aimed at helping to find markets for the small-diameter, overmature lodgepole pine; for aspen; for logging and milling residues; and for the relatively large quantity of killed spruce in the central Colorado Rocky Mountain area.

Forest Survey

The rate of progress of the cooperative Forest Survey project indicates that field work in Colorado and Wyoming will be completed by 1960. The 1957 schedule of 700 volume sample plots was completed in addition to other basic work by National Forest Resource Management on forest type and condition mapping.

Plot work was finished on the Medicine Bow and Hayden divisions of the Medicine Bow National Forest, about 80 percent of the Grand Mesa-Uncompahgre National Forest, and all of the Routt and Roosevelt National Forests. Volume plot work has been completed on about 45 percent of the national-forest area of the two States.

New or recent aerial photographs have been obtained on almost all of the national-forest area. Photo interpretation is now being done in preparation for sample plot work on the Bighorn, Arapaho, Grand Mesa-Uncompahgre, Pike, and San Isabel National Forests in the summer of 1958. Other work now in progress, in cooperation with the U. S. Bureau of the Census, includes the survey of timber cut and lumber produced in 1957.

PUBLICATIONS

Watershed Management Research

DECKER, J. P.

Further evidence of increased carbon dioxide production accompanying photosynthesis. Jour. Solar Energy, Sci., and Engin. 1: 30-33, illus., January 1957.

Curves of CO_2 uptake vs. light intensity and of CO_2 uptake vs. CO_2 concentration (for tobacco and eight other plant species) can be interpreted as demonstrating that respiration was severalfold faster during photosynthesis than in darkness. The interpretation has important bearing on the quantum efficiency and other theoretical aspects of photosynthesis.

_______ and WETZEL, G. F.

A method for measuring transpiration of intact plants under controlled light, humidity, and temperature. Forest Sci. 3: 350-354, illus., December 1957.

A laboratory method is described for measuring transpiration by the amount of water vapor produced. An infrared gas analyzer serves as a sensitive and fast-acting hygrometer. The method appears adaptable to field use.

DORTIGNAC, E. J.

Water yields through watershed management in New Mexico. New Mex. Water Conf. Proc. 1956: 69-97, illus., August 1957.

Discusses the relation between precipitation and runoff by climatic and vegetation zones in New Mexico; the opportunity for improving water yields through management on the basis of research findings; and the need for additional research information for guiding and improving watershed management practices.

HOOVER, M. D.
Water yield research by the Rocky Mountain Forest and Range Experiment Station. Pacific Southwest Inter-Agency Committee Minutes 56-4(B): 14-20, November 1956.
(Not listed in the station's 1956 annual report)

Reviews results of past research and describes tests in progress.

PRICE, RAYMOND, and HOOVER, M. D.
Watershed management research in Arizona conducted by the Forest Service. Ariz. Watershed Program Proc., Ariz. State Land Dept. 1: 5-10, illus., September 1957.

Highlights of countrywide and regional watershed management research. Brief description of current research in Arizona by vegetation types.

Forest Management Research

ALEXANDER, R. R.
Preliminary guide to stand improvement in cutover stands of spruce-fir. Research Note 26, 6 pp. April 1957.

Only trees making satisfactory use of available growing space, with a favorable chance of surviving in good health to rotation age are recommended as leave trees.

____
Damage to advanced reproduction in clearcutting spruce-fir. Research Note 27, 3 pp. June 1957.

Adequate spruce regeneration survived logging on north slopes, but without subsequent spruce regeneration the replacement stand on west slopes will be largely fir.

GEORGE, E. J., READ, R. A., JOHNSON, E. W., and FERBER, A. E.
Shelterbelts and windbreaks. U. S. Dept. Agr. Yearbook 1957: 715-721.

Discusses the interrelationships of Great Plains windbreaks and their environment. Gives pointers on care of plantings.

MYERS, C. A.
Cubic-foot volume table for immature ponderosa pine in the Black Hills. Research Note 25, 2 pp. February 1957.

Presents cubic-foot volumes for trees 1 to 19 inches d.b.h. and 10 to 100 feet tall.

READ, R. A.
Effect of livestock concentration on surface-soil porosity within shelterbelts. Jour. Forestry 55: 529-530. July 1957.

Showed that soil bulk density was significantly greater, and large pore space significantly less in heavily trampled portions as compared to protected portions of shelterbelts.

SHAW, E. W.
A new look at shelterbelts. Amer. Forests 63(12): 18-19, 47-49, illus., December 1957.

Summarizes in popular style the results of the 1954 resurvey of the Great Plains shelterbelts.

Forest Disease Research

ANDREWS, S. R.
Dwarfmistletoe of ponderosa pine in the southwest. U. S. Dept. Agr. Forest Pest Leaflet 19, 4 pp., illus., September 1957.

Briefly describes the parasite and its effects on host trees. Discusses methods of control.

GILL, L. S.
Dwarfmistletoe of lodgepole pine. U. S. Dept. Agr. Forest Pest Leaflet 18, 7 pp., illus., September 1957.

Describes the parasite, its ecology, and effects on host trees. Discusses methods of control.

MASSEY, C. L.
Four new species of Aphelenchulus (nematoda) parasitic in bark beetles in the United States. Helminthol. Soc. Wash. Proc. 24: 29-34, illus., January 1957.

Description of four new species of nematode parasites occurring in the body cavity of bark beetles.

NAGEL, R. H., McCOMB, D., and KNIGHT, F. B.
Trap tree method for controlling the Engelmann spruce beetle in Colorado. Jour. Forestry 55: 894-898. December 1957.

When felled in the fall and in the shade, trap trees are effective supplements to chemical control.

OSTMARK, H. E.
Forest insect conditions in the central Rocky Mountains, 1956. Station Paper 27, 14 pp., illus., June 1957.

Summarizes the status and trend of major forest insect pests in Colorado, Wyoming, South Dakota, Nebraska, and Kansas.

YASINSKI, F. M.
Pilot test of ethylene dibromide in an oil solution for control of roundheaded pine beetle, Coconino National Forest -- 1956. Research Note 29, 2 pp. December 1957.

Pilot test of ethylene dibromide in fuel oil was successful in treating infestations of roundheaded pine beetle. Treating cost averaged $5 a tree.

________ and PIERCE, D. A.
Forest insect conditions in Arizona and New Mexico -- 1956. Station Paper 26, 18 pp., illus., June 1957.

A summary of detection and appraisal surveys and results of control programs in 1956.

Forest Utilization Research

FECHNER, G. H.
A survey of the pole resource in the northern Black Hills. Station Paper 28, 12 pp., illus., December 1957.

Discusses the method of survey and indicates that 90,000 poles are available annually for expansion of the pole industry.

Range Management Research

ANDERSON, D., HAMILTON, L. P., REYNOLDS, H. G., and HUMPHREY, R. R.
Reseeding desert grassland ranges in southern Arizona. Ariz. Agr. Expt. Sta. Bul. 249, 32 pp., illus. (Revised March 1957.)

Sites, species, and methods of establishment are recommended for deteriorated desert grassland ranges of southern Arizona.

BOHNING, J. W.
What will burning do for your semidesert range? Ariz. Stockman XXII(11): 14-15, illus., November 1956. (Not listed in the station's 1956 annual report)

Points out that some undesirable plants are more susceptible to fire than others. The same is true of grasses. Fire may be used where brush is very susceptible and where fire-tolerant grasses predominate.

CABLE, D. R.
Effect of mesquite clearing on perennial grass forage production. In Range Day, Santa Rita Experimental Range, Continental, Arizona. 1957: 6a-6b. October 1, 1957.

Killing mesquite with diesel oil costs about 5 cents a tree. Killing mesquite has not yet increased the density of perennial grasses but has resulted in higher yields of herbage.

———. Recovery of chaparral following burning and seeding in central Arizona. Research Note 28, 6 pp., illus., November 1957.

Chaparral species sprouted rapidly following burning. Shrub sprouts covered 22 percent of the ground surface 14 months after a wildfire and 37 percent 5 years after the fire. Weeping lovegrass seeded by plane developed into a good stand, in association with the sprouting shrubs. The grass has continued to increase in density for the 5 years following seeding.

———. Chemical control of chaparral shrubs in central Arizona. Jour. Forestry 55: 899-903, illus., December 1957.

Reports on the reaction of sprouting chaparral species to application of ammate and brush killer (50-50 mixture of 2, 4-D and 2, 4, 5-T). Effective control of all species was obtained by two applications 2 years apart of 5.8 percent solution of brush killer in diesel oil applied as basal spray.

CANFIELD, R. H.
Reproduction and life span of some perennial grasses of southern Arizona. Jour. Range Mangt. 10: 199-203, illus., September 1957.

Primary forage grasses are more abundant on areas that receive light or no grazing. Both secondary and primary grasses produced some new plants each year, but secondary species usually produced greater numbers. Some black grama plants survived as long as 14 years, but Rothrock grama lived only 3 years.

MARTIN, S. C.
To control mesquite economically, start early and keep at it. Ariz. Cattlelog XIII(6): 22-26, illus., February 1957.

Points out that although scattered stands of small mesquite are not striking, they are the most economical to control. Early control prevents declines in forage production that will surely come if mesquite is allowed to form dense stands of mature trees.

———— Responses of native and introduced grasses following aerial spraying of mesquite. In Range Day, Santa Rita Experimental Range, Continental, Arizona. 1957: 7a-7c. October 1, 1957.

Spraying mesquite with 3/4 pound of 2, 4, 5-T per acre by air in two successive years greatly increased herbage production of native perennial grasses. Lehmann lovegrass, seeded by airplane the day of the first spraying, has established a good stand in areas that were formerly bare. Increased herbage production during the four growing seasons since treatment appears to be almost enough to defray the cost of treatment.

———— The Santa Rita Experimental Range. In Range Day, Santa Rita Experimental Range, Continental, Arizona. 1957: 2a-2c. October 1, 1957.

Describes the Santa Rita Experimental Range, tells how it is administered, lists major range problems, and outlines present research program.

———— Range readiness. Ariz. Cattlelog XIII(4): 46-49. December 1957.

Grazing too heavily or at the wrong time can seriously injure valuable forage plants. Grasses are especially susceptible to grazing damage in the early spring and at the time seed heads are forming. Since occasional grazing at the wrong season is unavoidable, the rancher must offset these periods of improper use by appropriate rest periods. He should avoid grazing the same spots and the same plants at the same time every year.

PAULSEN, H. A., JR.
Some effects from controlled burning on a grass-shrub range. In Range Day, Santa Rita Experimental Range, Continental, Arizona. 1957: 4a-4c, illus., October 1, 1957.

June burning was very effective in killing burroweed, moderately effective in pricklypear and cholla cacti, but ineffective in mesquite. A single burn reduced the perennial grass density by about one-third during the first growing season, but by the end of the second growing season most of this loss was regained. A second burn produced results similar to those of the first burn. Some grasses including black grama are very susceptible to fire; others, like the three-awns, recover fairly rapidly.

PINGREY, H. B., and DORTIGNAC, E. J.
Cost of seeding northern New Mexico rangelands. New Mex. Agr. Expt. Sta. Bul. 413, 43 pp., illus. December 1957.

Gives the costs involved in seeding deteriorated rangelands in north-central New Mexico and seeding cropland on a rancher-farmer basis in northeastern New Mexico. Also discusses aspects of range seeding which the rancher or farmer should consider when deciding to seed land, climatic factors affecting choice of grass species, methods to be used, and the best time for planting.

REID, E. H.
Eighteen years of change on a subalpine grassland in Oregon. Ecol. Soc. Amer. Bul. 38(3): 72. September 1957.

An abstract of a paper presented at the Forty-Second Annual Meeting of the Ecological Society of America.

____
Some plant distribution problems in range management. Jour. Colo.-Wyo. Acad. Sci. 4(9): 55. December 1957.

An abstract of a paper presented at the Twenty-Eighth Annual Meeting of the Colorado-Wyoming Academy of Science.

REYNOLDS, H. G.
Range reseeding practices in Arizona. Ariz. Cattlelog XII(10): 28-30, illus., June 1957.

Reseeding recommendations for ponderosa pine, big sagebrush, pinyon-juniper, and desert grassland ranges are briefly discussed.

____
Porcupine behavior in the desert-shrub type of Arizona. Jour. Mammal. 38: 418-419. August 1957.

A recent observation suggests that porcupines have become adapted for survival in the desert-shrub type of the Southwest. Ocotilla may be an important food for porcupine in this area.

_______ and TSCHIRLEY, F. H.
Get rid of those mesquite--now. Ariz. Stockman XXII(7): 15, 31, 36, illus., July 1956.
(Not listed in the Station's 1956 Annual Report)

The main principles to be observed in a mesquite eradication program are: (1) Treat those sites first where the greatest forage response can be expected; (2) complete eradication of mesquite from a range unit in preference to partial control; (3) eradication of the lightest stands pays the biggest dividends.

_______ and TSCHIRLEY, F. H.
Mesquite control on southwestern rangeland. U. S. Dept. Agr. Leaflet 421, 8 pp., illus., October 1957.

Discusses the detrimental effects of mesquite, the value of control, and the types of stands most suitable for control by grubbing, basal oiling, mechanical clearing, and airplane spraying.

SPRINGFIELD, H. W.
Forage problems and resources of Iraq. Internatl. Coop. Admin., Wash. D. C. 37 pp., illus., April 1957.

Forage supplies are generally adequate from February through June but become critically short during the August-January period. From 70 to 100 percent of the livestock feed requirements are furnished by native forage plants. Most cultivated forage crops are managed as "soiling crops" wherein the plants are cut and fed in a fresh green condition.

General

READ, R. A.

Review of "Shelterbelts and microclimate" by J. M. Caborn. Forest Sci. 3: 373-374, December 1957.

A review of Department of Forestry, Edinburgh University, Forestry Commission Bulletin 29, published 1957. A 135-page treatise by a forest meteorologist summarizing past research on the influences of windbreaks upon microclimate of adjacent areas.

REYNOLDS, H. G.

Review of "Grasslands of the Great Plains" by J. E. Weaver and F. W. Albertson. Sci. Monthly. 85 (2): 108-109. August 1957.

Reviews the mid- and short-grass prairie which extends from southern Texas to Saskatchewan, an area 2, 500 miles long and 400 miles wide.

____

Review of "Manual for analysis of rodent populations" by David E. Davis. Jour. Range Mangt. 10: 284. November 1957.

Reviews an arbitrary trapping technique for studying small rodent populations.

RICH, L. R.

Review of "Dendroclimatic changes in semiarid America" by Edmund Schulman. Jour. Forestry 55: 148-149. February 1957.

Emphasizes the value of this progress report of original observations to anyone interested in longtime rainfall and runoff trends.

SHAW, E. W.

Publication ideals. Tech. Writers' and Editors' Jour. Summer issue, p. 7, illus., August 1957.

A brief editorial on problems in writing, editing, and publishing.

______ New book tells how to grow Christmas trees. The Green Thumb 14: 297. September 1957.

A review of "Christmas trees for pleasure and profit" by A. G. Chapman and R. D. Wray.

STATION STAFF

Annual report, 1956. Rocky Mountain Forest and Range Experiment Station. 119 pp., illus., February 1957.

Outlines research progress at the station during 1956.